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INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8½" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in this volume will serve as a style guide for submissions (address format, etc.).

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Research Associate, Dept. Invertebrate Zoology, Los Angeles County Natural History Museum, 900 Exposition Blvd., Los Angeles, California 90007.

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SOURCES OF OCEANOGRAPHIC, GEOLOGIC, AND MOLLUSCAN DATA FOR THE NORTHERN GULF OF CALIFORNIA AND THE SALTON TROUGH OF SOUTHERN CALIFORNIA

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ABSTRACT

Much research has been done on the Gulf of California and its living fossil mollusks, but the information is widely scattered in published and unpublished sources, and in institutional and private collections. Selected references are given here for oceanographic and molluscan data for the northern Gulf of California and Salton Trough of California to facilitate organizing these data for applications to problems such as the geologic history of the Gulf and lower Colorado River Valley.

Introduction

Paleontological studies in west Mexico and southern California indicate that the early Gulf of California and its northern extension to the Salton Trough of southern California had a variety of biofacies in the past 10-12 million years. The fossil mollusks include Caribbean, Pacific-Panamic, and endemic forms, some of which became extinct and others that evolved to taxa living in the Gulf today.

Although many observations have been made, much information on the living fauna is not readily accessible. To help assess what is known about the modern mollusks, a symposium was convened at the annual meeting of the Western Society of Malacologists in San Diego; its focus was molluscan distributions and oceanographic features in the Gulf of California north of Bahía de Los Angeles, Baja California and Isla Tiburon, Sonora, and the Tertiary marine paleontology of the Salton Trough of southern California, the area between 28° N and 34° N (Figure 1).

Contributors to the symposium were asked to report on molluscan assemblages, distributions, and habitats, and to include temperature, salinity, and current measurements where available, since most of the published oceanographic data from the gulf are from the central and southern parts. Future distribution studies need to incorporate a vast amount of unpublished data from field notes, cruise logs, theses, museum holdings, and the collective experience of many observers who have dredged, dived, and collected by hand.

Symposium speakers were asked to consider their molluscan data within the context of one or more of the following questions: What mollusks live in the northern Gulf, and what are the differences between assemblages from Sonora and Baja California? What fossil mollusks are found in rocks between Isla Tiburon and San Gorgonio Pass in California? What offshore mollusks commonly migrate to the intertidal to spawn? When do they come and how long do they stay? What are the water temperatures during the migration season, and during the extremes of winter and summer? Are any of the mollusks that live in the northern Gulf "trapped taxa" that also occur in southern California but not in the central and southern Gulf? What are the provincial affinities of the living and fossil species of the area? Does the "Caribbean connection" reported in the paleontological literature hold at the species level? Which mollusks are found during periods of cold water upwelling, and do these areas constitute barriers to the dispersal of warmer water mollusks? What effect does the Colorado River have on molluscan communities in the northern Gulf?

Geological Applications of Molluscan Data

In addition to contributing to ecologic and phylogenetic studies, data on modern molluscan distributions and habitats have important implications for the geologic history of the northern Gulf. They are clues to the configuration and character of ancestral embayments. Index fossils associated with radiometrically datable volcanic rocks date the earliest marine embayment in the ancestral Gulf as late middle Miocene (Smith and others, 1985) and provide a time frame for faulting and other events in the structural evolution of the area. Marine fossiliferous rocks associated with radiometrically datable volcanic rocks in the Salton Trough indicate that the Colorado River first entered the area about 4 million years ago (Damon and others, 1978; Winker and Kidwell, 1986), but the precise timing of regional uplift and faulting have yet to be determined (Lucchitta, 1979).

Structurally, the Gulf of California is a very complex area between the San Andreas fault system to the north and the East Pacific Rise to the south. It includes the boundary between the Pacific and North American Plates, but is partly related to the Basin and Range Province of California (Dokka and Merriam, 1982). Geophysical data support the interpretation that the Baja California peninsula lay against the Mexican mainland until about four million years ago (Larson, 1972), after which time a series of faults and spreading centers developed (Klitgord and others, 1974; Curray and Moore, 1984), producing the bottom profiles illustrated in Shepard (1950), Rusnak and others (1964), and Maluf (1983). Abundant Tertiary marine mollusks in many sedimentary sections throughout the Gulf and

Salton Trough permit correlation between discontinuous basins and terranes separated by later faulting.

Controversial Topics in the Northern Gulf Area

Many mollusks that have been reported as living "throughout the gulf" are found south of Guaymas and Bahía de los Angeles; some are present seasonally, others only during periods of upwelling or downwelling. Symposium contributions by D. K. Mulliner on the effects of upwelling on faunas and by N. Vaughan on species of *Turritella* living in cool water at the mouth of the Mulege estuary and spawning intertidally at Bahía Cholla suggest seasonal migrations; J. Gemmell noted that *Turritella anactor* Berry, 1957, mainly an offshore species, migrates during the spring to spawn in the intertidal at San Felipe. Such observations account for some of the discrepancies in reported depth and habitat data and underscore the importance of accurate distributional and ecologic details and the date of collection.

Fossils from the ancestral northern Gulf include many species with Caribbean affinities. Degrees of similarity between these taxa need to be quantified and their ancestors identified so that geographic distributions can be determined for phylogenetic series through time. Many species from the Imperial Formation of California have been referred to Caribbean taxa; their absence from known faunas of Panama and Costa Rica raise questions of how they reached the northern Gulf and whether another as yet unidentified seaway once connected the Caribbean with the Gulf of California.

The age of the Imperial Formation of southern California has been controversial since the earliest faunal studies, which are summarized by Powell (1986). Considered Eocene to Plio-Pleistocene by various authors, its age is now bracketed in a few places as older than 6 million years (Matti and others, 1985) and younger than 16 ± 1.0 million years (Eberly and Stanley, 1978), or, late middle or late Miocene to early Pliocene.

The Imperial Formation was deposited in discontinuous embayments around and over irregular topography from the Sierra de los Cucupas, Baja California, and the Yuha Buttes and Coyote Mountains, Imperial County, to San Gorgonio Pass in Riverside County, California. Studies by Bell-Countryman (1984) and Powell (1985, 1986, this volume) suggest a greater variety of biofacies than recognized by early workers, and the possibility that ecological factors rather than time account for some of the differences in assemblages from different parts of the Salton Trough. Some species of the fossil mollusks from the upper middle Miocene section at Isla Tiburón (Stump, 1981a; Smith and others, 1985; Smith, in press) are also represented at San Gorgonio Pass and at Alverson Canyon in the Coyote Mountains. With the radiometric ages cited above and possible foraminiferal evidence from the Cerro Prieto geothermal field southeast of Mexicali (Cotton and Vonder Haar, 1980), molluscan data suggest that the Imperial Formation may be as old as late middle Miocene in some places and span a longer period of time than previously recognized. Small clams, oysters, and plant remains have been reported from the Imperial Formation of the western Sierra de los Cucupas southwest of Mexicali, Baja California (Barnard, 1968), but specimens are sparse and poorly preserved.

Oceanography and Marine Geology of the Northern Gulf of California

Although the northern Gulf of California is mainly shallow (50-200 m in depth), a number of basins and deep channels lie along the western side (Shepard, 1950; Rusnak and others, 1964; Maluf, 1983). The basins are believed to have formed in connection with crustal extension along faults and spreading centers (Henyey and Bischoff, 1973; Klitgord and others, 1974); from north to south they include Wagner Basin, southeast of Consag Rock, Delfin Basin, the Salsipuedes channel (1400 m deep), Tiburon Basin, San Esteban Basin, and Guaymas Basin.

General bathymetric, salinity, and temperature data are summarized by Maluf (1983) following Roden (1964) and Roden and Groves (1959). Surface and subsurface temperatures are recorded by Robinson (1973); temperature, current, salinity, turbidity, and primary productivity data for the northern Gulf are published in Hendrickson (1974). Faunal, oceanographic, and habitat data are synthesized by Parker (1964a, 1964b) for the entire Gulf, Barnard and Grady (1968) for Bahía de los Angeles, and by Thomas and Beatrice Burch (unpublished analyses) for 644 stations at Puerto Peñasco collected from 1966-1969.

More detailed records are available for Bahia Cholla, 10 km west of Puerto Penasco, and vicinity, a seven square km intertidal area of sand, mudflats, tidal channels, rocky substrate, and salt marsh with tidal amplitudes up to 7 m. Information sources include Hendrickson (1974), Matthews (1968), and the results of ongoing research on zonation and taphonomy by K. W. Flessa and F. T. Fursich (abstract, this volume), Flessa (1987) and by Peggy Turk Boyer and workers at CEDO, the Center for the Study of Deserts and Oceans (Apartado Postal 53, Puerto Peñasco, Sonora, Mexico 83550 or, c/o ERL, University of Arizona, Tucson International Airport, Tucson, Arizona 85706). Tide calendars for the northern Gulf are prepared annually by the Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona 85721.

A review volume by van Andel and Shor (1964) contains a number of geophysical, oceanographic, and zoogeographic papers on the Gulf of California; an updated version is in preparation (J. P. Dauphin, ed., 1988).

Although the effects of El Niño/Southern Oscillation phenomena on fish and mollusks have been noted in the northern Gulf (D.K. Mulliner abstract, this volume) quantitative investigations have yet to be made. Sediments were sampled for biological and physical responses to the 1983 El Niño event in the central Gulf of California by scientists from the Centro de Investigación Cientifica y de Educación Superior de Ensenada (C.I.C.E.S.E.). Results show that increased phytoplankton blooms resulting from periods of intensified cold water upwelling are recorded in fine grained laminated sediments in the western Gulf (T. Baumgartner, J. Ma. Robles P., and R. Lara L., 1987, written communication), just as they are in basins off southern California (Casey and others, 1987).

General circulation patterns in the Gulf are northerly along mainland Mexico, south along eastern Baja California, but local and seasonal shifts in this pattern are of great significance to faunal dispersal and colonization. Certain molluscan species are restricted to periods of upwelling and downwelling, especially those accentuated by El Niño/Southern Oscillation events such as in 1983 and during a lesser episode in 1964. Strong tidal currents in the northern Gulf rework and redeposit Colorado River sediments, producing turbid water from the head of the Gulf to Puertecitos.

Mollusks From the Modern and Ancestral Northern Gulf of California

General references including Holocene molluscan distributional data but not restricted to the northern Gulf are Parker (1964a, 1964b), Skoglund (1970), Keen (1971), Hertlein and Strong (1940-1950), Emerson and Puffer (1957) and Durham (1950). A summary of the marine pelecypods from San Felipe and vicinity, Baja California, was published by Gemmell and others (1987), and a companion list of gastropods, including habitat and spawning data, is in preparation by these authors. Checklists for other areas of the Gulf were published for Puerto Peñasco (Lowe, 1933, 1935), Consag Rock (DuShane and Brennan, 1969), Puertecitos (DuShane, 1962), Bahía San Luis Gonzaga (DuShane and Sphon, 1968), and Bahía de los Angeles (McLean, 1961; Coan, 1968; Barnard and Grady, 1968; Poorman and Poorman, 1978). For comparison with the northern Gulf mollusks, see the checklists for Guaymas, Sonora (Shasky and Campbell, 1964; DuShane and Poorman, 1967).

Institutions in California that house extensive collections of northern Gulf of California mollusks include the California Academy of Sciences, San Francisco, University of California, Berkeley; the Los Angeles County Museum of Natural History, the San Diego Museum of Natural History (includes the Gemmell collection), and the Santa Barbara Museum of Natural History (includes the collection of S. Stillman Berry). Additional records are included in the collections of a number of individuals who have devoted many years to working in the northern Gulf of California: Carol Skoglund, Roy and Forrest Poorman, Donald Shasky, Laura Shy, Helen DuShane, Tom and Beatrice Burch, and David Mulliner.

Mollusks from Pleistocene terrace deposits in the northern Gulf provide distributional data for the past 1 or 2 million years. Faunas from Puerto Peñasco are listed by Hertlein and Emerson (1956) and are under further investigation by Flessa and Fursich (abstract this volume). Assemblages from elsewhere in Sonora are listed for Puerto Libertad (Stump, 1975) and southeastern Isla Tiburón (Stump, 1981a). Quaternary marine terraces are shown on the geologic map of Baja California (Gastil and others, 1973) between Bahía de los Angeles and Bahía las Animas and in the vicinity of San Felipe and Puertecitos. Marine sediments of probable Pliocene age are reported west and north of Punta San Francisquito (Gastil and others, 1973), from northeastern, central and southern Isla Angel de la Guarda (Gastil and others, 1973; Emerson and Hertlein, 1964), and southwest of the isthmus of Isla Partida and on eastern Isla San Esteban, north of Arroyo Limontour (Emerson and Hertlein, 1964).

Potentially a source of confusion in documenting Pleistocene and Holocene distributions and habitats are kitchen middens such as one reported from Bahía San Luis Gonzaga by Coan (1965), reworked Pleistocene fossils such as at Puerto Peñasco (Flessa and Fursich, this volume), and abnormal occurrences of offshore taxa far inland (Squires and Thor, 1984). *Ficus ventricosa* (Sowerby, 1825), among other offshore forms, was transported inland during extreme spring tides and deposited with intertidal and nonmarine organisms; if fossilized, such an assemblage would constitute an aberrant association of forms from deeper water, tidal flats, and intermittent streams deposited in deltaic sediments.

Tertiary marine megafossils from the Imperial Formation represent the fauna of the ancestral northern Gulf; papers illustrating this fauna include those of Vaughan (1917), Durham (1950), Hanna (1926), Emerson and Puffer (1957), Schremp (1981), and Powell (1985). Important faunal data are included in the theses of Anderson (1973) for the area west of San Felipe, Baja California and Powell (1986) for the northern Salton Trough of California. Additional information on the San Felipe section is given in Hertlein (1968) and in a summary of Tertiary marine mollusks from the Gulf of California (Smith, in press). The oldest mollusks from the ancestral northern Gulf come from an upper middle Miocene unnamed marine conglomerate on southwestern Isla Tiburon (Stump, 1981a; Smith and others, 1985; Smith, in press).

The Salton Trough and Lower Colorado River areas, at times inundated by the ancestral Gulf of California, also had periods of nonmarine deposition. This history is recorded by distributions of terrestrial and freshwater mollusks, whose ranges suggest former drainages and paleoclimatology in southern California, Arizona, and Nevada. Subsurface records from wells show changes from marine to brackish to nonmarine conditions as embayments of the ancestral Gulf extended and retracted to the east and north of the present Salton

Trough (Metzger, 1969; Smith, 1970; Winterer, 1975). References to freshwater mollusks include Taylor (1954, 1983, 1985). Distributions of terrestrial mollusks of Baja California are the subject of a monograph in preparation by A. G. Smith, W. B. Miller, C. C. Christensen, and Barry Roth.

The Need For an Organized Database

Gathering, organizing, and synthesizing biological, ecological, and paleontological information on the mollusks of the Gulf of California requires the establishment of a more complete, well organized database for species that incorporates a variety of physical and biological information. Molluscan data will not be readily applicable to larger questions such as the history of the lower Colorado River area and the evolution of the Gulf of California until they can be analyzed quantitatively and considered in the context of both time and space.

Acknowledgments

Many individuals contributed information to this summary, particulary the speakers and audience at the northern Gulf of California symposium held 22 June 1987 as part of the Western Society of Malacologists Annual Meeting in San Diego, California. I thank all those who shared information, publications, and insights, and especially Carole M. Hertz, President of the Western Society of Malacologists, for her support of the program chairmen.

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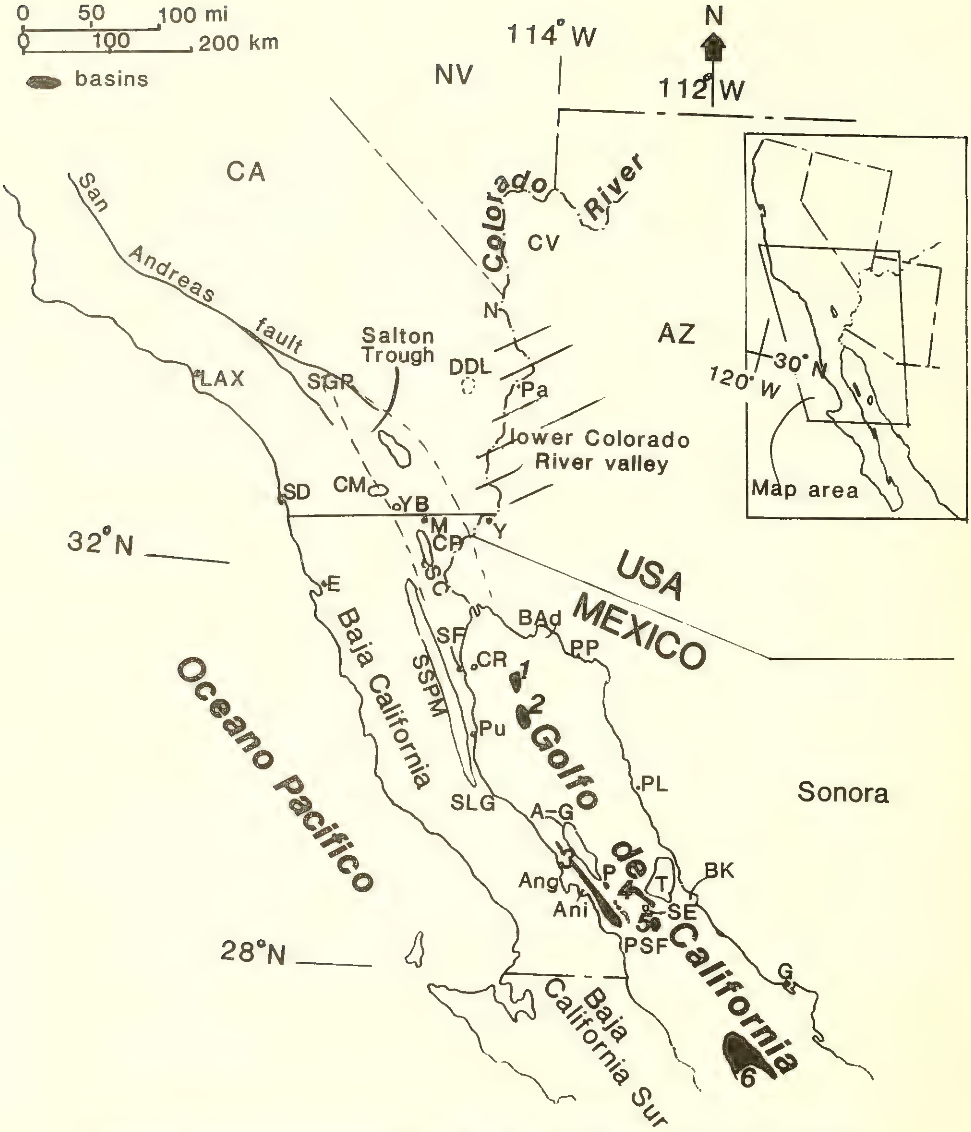

FIGURE 1. GEOGRAPHIC INDEX MAP, MODERN AND ANCESTRAL GULF OF CALIFORNIA

MEXICO:

A-G, Isla Angel de la Guarda; BAd, Bahía Adair; BK, Bahia Kino; CP, Cerro Prieto geothermal field; CR, Consag Rock; E, Ensenada; G, Guaymas; M, Mexicali; Ani, Bahía las Animas; Ang, Bahía de los Angeles; P, Isla Partida; Pu, Puertecitos; PL, Puerto Libertad; PP, Puerto Peñasco and Bahía Cholla (Choya Bay); PSF, Punta San Francisquito; SC, Sierra de los Cucupas; SE, Isla San Esteban; SF, San Felipe; SSPM, Sierra San Pedro Martir; SLG, Bahía San Luis Gonzaga; T, Isla Tiburon.

BASINS: 1, Wagner; 2, Delfin; 3, Ballenas and Salsipuedes channels; 4, Tiburón; 5, San Esteban; 6, northern end of Guaymas basin.

U.S.A.

CM, Coyote Mountains and Alverson Canyon; LAX, Los Angeles; N, Needles, CA; Pa, Parker, AZ; CV, Cottonwood Valley; DDL, Danby Dry Lake; SD, San Diego; LAX, Los Angeles; SGP, San Gorgonio Pass; Y, Yuma; YB, Yuha Buttes.

INFLUENCE OF UPWELLING IN THE GULF OF CALIFORNIA AS NOTED BY SCUBA DIVING

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The Gulf of California is a 1000 km long trough-shaped basin. Depths in the central depression exceed 1200 meters. The Ballenas Trench, between Baja California and Isla Angel de la Guarda, reaches depths of 800 meters. Upwelling in the Gulf is primarily a phenomenon of the prevailing winds, which bring nutrient-rich water to or near the surface. The June to September southeasterly winds lead to upwelling along the Baja California coast and downwelling along the mainland Mexican coast. The reverse is true for the winter months when the northwesterly wind predominates. Observations made during SCUBA diving in periods of upwelling reveal dense algal growth, cold temperatures (64° F), poor visibility (33 m visibility normally, as little as 1 m visibility during upwelling), and abundance or paucity of certain invertebrates. Deeper water fish can frequently be seen at the shallow (15 m) thermocline created by upwelling along the coastal islands. Some molluscan taxa are seasonal, such as the nudibranch *Armina*, which is present in the early spring, and *Jenneria* and *Fusinus*, which disappear at the end of the summer when upwelling ceases.

MOLLUSCAN HABITATS OF THE SAN FELIPE AREA, BAJA CALIFORNIA, MEXICO

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Intertidal molluscan habitats in the northwestern Gulf of California from north of the town of San Felipe southward to San Luis Gonzaga are discussed. The topography of twelve beach areas are described with information on fauna, substrate, tidal range, seasonality and beach access. The data from this talk are published in Gemmell, Myers, and Hertz, 1987, ''A Faunal Study of the bivalves of San Felipe and environs, Gulf of California, from the Gemmel collection (1965-1976),'' supplement to the Festivus, vol. 18, 72 pp.

THE MIOCENE AND PLIOCENE IMPERIAL FORMATION OF SOUTHERN CALIFORNIA AND ITS MOLLUSCAN FAUNA: AN OVERVIEW

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ABSTRACT

The Miocene and Pliocene Imperial Formation contains both Caribbean and eastern Pacific molluscan taxa and is important for correlating upper Neogene rocks in southern California with those in Central and South America and in eastern North America. Two-hundred fifty-five mollusks are reported from the Imperial Formation in southern California. The Imperial Formation mollusks have strong Panamic affinities and more taxa in common with the Caribbean provinces than with the adjacent Surian and Peruvian provinces.

Introduction

The Imperial Formation was deposited at the head of the proto-Gulf of California during the late Miocene to late(?) Pliocene. The formation crops out discontinuously from just south of the California-Mexico border to north of Palm Springs, Riverside County, California (fig. 1). Outcrops in southern California can be separated into two groups: the northern exposures in Riverside County and the southern exposures in Imperial County, except for one additional outcrop at Willis Palm, Riverside County. The northern and southern outcrops are distinguished by geographic position in the ancestral Gulf of California, by age, and possibly by different environments.

Fossil mollusks from the Imperial Formation are still poorly known more than 130 years after they were first collected by Blake (1855) during the Pacific Railroad Survey. Mollusks from the Imperial Formation remained virtually unknown until the work of Hanna (1926) and Bramkamp (1935), at the southern and northern exposures, respectively. Since these early works only two papers have dealt in detail, with the mollusks of the Imperial Formation. Schremp (1981) reported on the archaeogastropods and Powell (1986) discussed the bivalves from the northern exposures.

The Imperial Formation is in a key location, both geographically and stratigraphically, to help unravel the evolution of the proto-Gulf of California and to aid in making correlations between coastal California and Central America, South America and the Caribbean. Because of our incomplete knowledge of Imperial Formation mollusks and poor age controls of marine rocks in the Gulf of California, its relationship to other marine formations in the Gulf are difficult to assess. The list of mollusks presented here provides information that will be useful in determining time(s) of deposition of the Imperial Formation, depositional environments, correlations between the eastern Pacific and the western Atlantic, and paleobiogeographic affinities of mollusks from the proto-Gulf.

To date, 255 mollusk taxa have been reported from the Imperial Formation (Table 1); it is assumed that all published taxonomic identifications are correct, unless there is strong evidence to the contrary. Because of the work of Powell (1986) the bivalves of the Imperial Formation are better known than the gastropods. Taxa not specifically identified (e.g. *Nucula* sp.) but which are found in both the southern and northern exposures of the Imperial

Formation, are combined in the table and may not represent the same taxon at each locality. Species listed in table 1 are arranged systematically according to the scheme of Moore (1969) for the bivalves and of Keen (1971) for the gastropods. Within each genus species are arranged alphabetically.

Stratigraphy

The Imperial Formation is exposed along the northern and western margins of the Salton Trough in the Colorado Desert (fig. 1). It is best represented in the south in the Fish Creek Mountains and Coyote Mountains where the type locality is located, and in the north from San Gorgonio Pass to Willis Palm. Although the stratigraphic relationship is similar, the mollusks from these two areas are rather dissimilar, indicating difference in age, depositional setting, and location in the proto-Gulf of California (Powell, 1986).

Two members of the Imperial Formation are traditionally recognized (Stump, 1972) and can be seen at many localities: a lower basal sandstone and conglomerate and an upper fine-grained sandstone and siltstone. A time-transgressive boundary separates the members from north to south and probably from the center of the basin to the margins. Winker (1987) recently subdivided the Imperial Formation into six informal members in the Valecitos-Fish Creek basin and related them to the rifting of the Gulf of California and development of the Colorado River in the Salton Trough. Winker's members may be of only local significance, regional stratigraphy must await further study.

The lower, Latrania Sand Member (Keen and Bentson, 1944) is generally composed of coarse- to medium-grained sandstone, with scattered conglomerate and coral reef beds in Imperial County. It attains a maximum thickness of about 180 m (Stump, 1972) in Imperial County and about 30 m in Riverside County (Powell, 1986). The molluscan assemblage from the Latrania Sand Member is characterized by euhaline species that lived in a moderate- to high-energy, intertidal to inner shelf, rocky to sandy habitat. The unnamed, upper member (=Lion Sandstone of Vaughan, 1922; =Coyote Mountain clays of Hanna, 1926; =Yuha Reefs of Hanna, 1926; and =Burrobend unit of Stump, 1972 and Foster, 1979) of the Imperial Formation is composed of sandstone and siltstone with associated oyster biostromes and bioherms. It attains a maximum thickness of 1,340 m in Imperial County (Stump, 1972) and 75 m in Riverside County (Powell, 1986). The upper member represents a low- to moderate-energy, inner- to outer-shelf environment which shallows upsection and may represent subaerial deposition at some outcrops.

Faunal Composition

Imperial Formation mollusks include both inner and outer tropical forms in the sense of Hall (1964). He used "outer tropical" for mollusks that live in a marine climate defined by about 4 months per year of shallow-water temperatures warmer than 20° C and not lower than 10° C for any prolonged period of the year, and "inner tropical" for "mollusks that live in water that is 20° C for 6 or more months, and with no months cooler than 18° C." Today, the entire Gulf of California lies within the outer tropical zone, as determined by water temperature measurements compiled by Robinson (1973).

Holocene molluscs that occur in the Imperial Formation and have southern Panamic affinities are now locally extinct in the Gulf of California include: *Chama buddiana* Adams, 1852, *Chama corallina* (Olsson, 1971), *Crassinella pacifica mexicana* Pilsbry and Lowe, 1932, and *Macoma siliqua* (Adams, 1852). These taxa, which are restricted to the inner tropics, suggest slightly warmer conditions during deposition of the Imperial Formation than are now present in the Gulf. There are no northern extralimital taxa in the Imperial Formation. Bivalves from the Imperial Formation in Riverside County that have living representatives exhibit the following biogeographic affinities: California molluscan province, 3.4%; Surian, 14.6%; Panamic (including the Gulf of California), 57.9%; Peruvian, 7.9%, and Caribbean, 16.2%. Modern mollusks from the Gulf have a slightly higher percentage with Californian affinities, but also have strong southern affinities (Cooper, 1895). In contrast, Durham (1950) studied later Neogene and Pleistocene mollusks from the Gulf and indicated that 10% have northern affinities and 30% have southern affinities (n=273).

The Imperial Formation has long been known to have strong Caribbean affinities (Bramkamp, 1935; Schremp, 1981; see also Vaughan, 1917 for the corals). The presence of Caribbean and South American mollusks and the lack of typical California taxa suggest that the marine connection supplying the water to the proto-Gulf, including the Salton Trough, was along the west coast of mainland Mexico, rather than through a late Neogene basin in southern California or Baja California Norte (Powell, 1986). Southern Central America was submerged during most of the late Neogene (Keigwin, 1978), allowing migration of Carribean taxa to the eastern Pacific. Taxa which are known only from the Caribbean and the Imperial Formation include: *Nuculana santarosaensis* Perrilliat, 1976, *Arcopsis adamsi* (Dall, 1886), *Ctenoides floridana* Pilsbry and Olsson, 1953), *Timothynus* n. sp., *Lophocardium gurabicum* (Maury, 1917), *Hemitoma emarginata* (Blainville, 1825), *Diodora cayenensis* (Lamarck, 1822), *Calliostoma olssoni* Maury, 1925, *Arene stephensoni* Schremp, 1981, and *Mirachelus imperialis* Schremp, 1981, and many others.

Age of the Imperial Formation

The age of the Imperial Formation has been controversial since it was first described, with ages ranging from Cretaceous (Orcutt, 1890; Vaughan, 1900) to late Pliocene (Downs and White, 1968; Mount, 1974). This problem stems from the endemic nature of the Imperial Formation fauna and the lack of knowledge of other late Tertiary faunas from the

Gulf of California. The problem has been complicated by the realization that the northern and southern exposures do not represent the same period of time. The age discrepancy is thought to correlate with position in the proto-Gulf of California and with two eustatic sea-level high stands when sediments were deposited north of the recent extent of Gulf waters (Powell, 1987).

Mollusks from the northern exposures of the Imperial Formation are of limited use in determining an age for the formation, although Bramkamp (1935) considered them to be middle Miocene in age. Taxa from the Imperial Formation in Riverside County that are restricted to the Miocene are *Myrakeena angermanni* (Hertlein and Jordan, 1927), *Lophocardium gurabicum* (Maury, 1917), *Semele sayi* Toula, 1909, and *Solecurtus gatunensis* (Toula, 1909). Mollusks previously known only from the Pliocene include *Anadara carrizoensis* Reinhart, 1943, *Argopecten mendenhalli* (Arnold, 1906), *A. sverdrupi* (Durham, 1950), *Lyropecten modulatus* (Hertlein, 1925), *Evola keepi* (Arnold, 1906), and *Callucina quincula* (Olsson, 1964). Pleistocene and younger bivalve mollusks from the Imperial Formation in Riverside County include: *Glycymeris delessertii* (Reeve, 1843), *Chama buddiana, Cardites crassicostata* (Sowerby, 1825) and *Crassinella pacifica mexicana.* Taxa not previously reported older than the Holocene include *Chlamys lowei* (Hertlein, 1935), *Leptopecten palmeri* (Dall, 1897), *L. velero* (Hertlein, 1935), *Chama corallina* and *Tellina pristiphora* (Dall, 1900). Taken together, these taxa suggest an age no older than middle Miocene, and possibly younger. A recent K-Ar age determination of about 6 Ma (Matti and others, 1985) on a basalt flow in the Painted Hill Formation that directly overlies the Imperial Formation and another from the underlying Coachella Fanglomerate of about 10 Ma (Peterson, 1975) support a late Miocene age for the Imperial Formation at Super Creek (fig. 1, no. 2). The co-occurrence of *Spondylus victoriae* Sowerby, 1859 *fide* Durham, 1950, *Myrakeenae angelica* (Rocheburne, 1895), *Atrina* n. sp., and *Flabellipecten* n. sp. at Super Creek, Lion Canyon and Garnet Hill suggests correlation between these sites.

The southern exposures of the Imperial Formation and the exposure at Willis Palm yield mollusks that are considered Pliocene in age. Mollusks restricted to the Pliocene in the Gulf of California and found in the Imperial Formation include: *Anadara carrizoensis, Glycymeris maculata* (Broderip, 1832), *Argopecten desertii* (Conrad, 1855), and *Flabellipecten carrizoensis* (Arnold, 1906). Benthic foraminifers from the basal Imperial Formation at Fish Creek also suggest that it is no older than earliest Pliocene (Ingle, 1974). Work by Johnson and others (1983), reinterpretating the magnetic stratigraphy of Opdyke and others (1977) suggests that the Imperial Formation in the Vallecito-Fish Creek basin is slightly older than 4.27 Ma and that deposition continued until about 4.0 Ma. Unfortunately, the lower member of the Imperial Formation is not exposed in the Vallecito-Fish Creek basin. The Imperial Formation in Imperial County and at Willis Palm is now considered to range from earliest Pliocene (Ingle, 1974; Stump, 1972) to possibly late Pliocene (Stump, 1972).

Conclusions

Most outcrops of the Imperial Formation in Riverside County differ in age from outcrops in Imperial County. Except at Willis Palm, the Riverside County deposits of the Imperial Formation are considered late Miocene in age, while in Imperial County and at Willis Palm in Riverside County the Formation is thought to be of Pliocene age. This discrepancy may be related to the site of deposition in the proto-Gulf of California and to two eustatic sea-level high-stands that flooded the northern Gulf.

Mollusks from the Imperial Formation lived in an outer tropical shelf habitat with possibly slightly warmer water temperatures than are present in the northern Gulf of California today. The Imperial Formation mollusks show strong southern affinities (Panamic and Peruvian provinces), with some taxa occurring in the Holocene and late Neogene faunas of the west coast of Central and South America, and the Caribbean. Paleobiogeographic affinities of the Imperial fauna refute a connection between the proto-Gulf of California and the eastern Pacific via the Los Angeles Basin or elsewhere in southern California or northern Baja California. Instead, the presence of Caribbean mollusks in the Imperial Formation suggest that, during the Miocene and most of the Pliocene, the Panama isthmus and possibly the Isthmus of Tehuantepec were submerged and that prevailing counter currents along the west coast of Mexico carried a shallow water marine fauna into the proto-Gulf of California.

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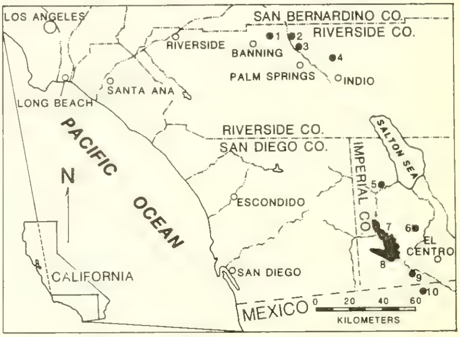

Figure 1: Outcrop distribution of the Imperial Formation in southern California. Outcrops in Riverside County are referred to as the northern exposures while those in Imperial County and in northern Baja California Norte are referred to as the southern exposures. Solid dots indicate outcrops too small for this scale of map. Numbers refer to outcrops of the Formation: 1) Lion Canyon, 2) Super Creek, 3) Garnet Hill, 4) Willis Palm, 5) San Felipe Hills, 6) Superstition Mountains, 7) Fish Creek-Valecitos, 8) Coyote Mountains, 9) Yuha Butts, 10) northern Cucupa Mountains, east of Mexicali, Mexico (Ingle, 1974). After Schremp, 1981.

TABLE 1: Mollusks reported from the Imperial Formation. Occurrences are as follows: LC=Lions Canyon; SC=Super Creek; GH=Garnet Hill; WP=Willis Palm; L=Latrania Sand Member; B=Unnamed upper member; U=undifferentated. References and footnotes are as follows: 1=Powell, 1986; 2=Stump, 1979; 3=Schremp, 1981; 4=Bramkamp, 1935; 5=Hanna, 1926; 6=Mount, 1974; 7=Woodring, 1931; 8=Hanna and Strong, 1949; 9=Kennedy, 1974; UCMP=University of California, Berkeley, Museum of Paleontology; UCR=University of California Riverside; po=personal observation in field.

TAXA	OCCURRENCE								REFERENCE
	Riverside County					Imperial County			
	LC	• SC •		GH	WP				
		L	B			L	B	U	
Mollusca:									
Bivalvia:									
Nucula sp			x				x		1, 2
Nuculana (*Saccella*) *mexicana* Perrilliat [as *N. acuata* (Conrad)]			x						1
Arca (*A.*) *mutabilis* (Sowerby)		cf	cf						1

TAXA	OCCURRENCE								REFERENCE
	Riverside County					Imperial County			
	LC	• SC •		GH	WP				
		L	B			L	B	U	
A. (A.) pacifica (Sowerby)		x	x			x			1, 2
Barbatia (Calloarca) n. sp.		x	x						1
Anadara (Anadara) carrizoensis Reinhart					x	x			1, 2
A. (A.) concinna (Sowerby)	x		x						1
A. (A.) n. sp.			x						1
A. (Esmerarca) reinharti Lowe						x			UCMP
A. (Grandiarca) grandis (Broderip and Sowerby)						cf			2
A. (Larkinia) multicostata (Sowerby)						x			2
A. (Rasia) formosa (Sowerby)						x			2
A. (R.) n. sp.						x			2
Arcopsis adamsi (Dall)			cf						1
Glycymeris (Axinactis) delessertii (Reeve)			cf						1
G. (A.) multicostata (Sowerby)						x			2
G. (G.) gigantea (Reeve)						x			2
G. (G.) maculata (Broderip)					x				1, 2
G. (G.) n. sp.		x	x						1
Tucetona (Bellaxinaea) n. sp.			x						1
Brachidontes sp.			x						1
Modiolus? sp.			x						po
Lithophaga (Diberus) plumula (Hanley)						x			2
Crenella inflata (Carpenter)			x						1
Atrina stephensoni Hanna						x			3
A. n. sp.			x			x			1
Pinna (Pinna) latrania Hanna			x			x			1, 2
P. mendenhalli Hanna						x			2
Cyclopecten pernomus (Hertlein)			cf						1
Argopecten abietis (Jordan and Hertlein)		cf							1
A. desertii (Conrad)							x		5
A. mendenhalli (Arnold)		cf							1
A. sverdrupi (Durham)		x							1
Chlamys corteziana Durham		x	x				x		1
C. lowei (Hertlein)			x						1
C.? mediacostata (Hanna)								x	5
Leptopecten palmeri (Dall)					x				1
L. velero (Hertlein)					x				1
Lyropecten modulatus (Hertlein)		x							1
L. subnodosus (Sowerby)								x	5
Evola keepi (Arnold)		x	x			x	x		1
Flabellipecten carrizoensis (Arnold)						x			2
Flabellipecten n. sp.		x	x						1
Pecten n. sp.		x							1
Patinopecten dilleri (Dall)								x	6
Plicatula penicullata Carpenter			x						1
Spondylus bostrythes Guppy						x			2, 3
S. calcifer Carpenter						x			2
S. victoriae Sowerby *fide* Durham, 1950	x	x	x	x		x			1
Anomia peruviana d'Orbigny			x			x	x		1, 2
A. subcostata Conrad							x	x	po, 5
Placunanomia hannibali Jordan and Hertlein							x		po
Ctenoides floridana Olsson and Harbison		x	x						1
Lima caribbaea (d'Orbigny)		cf	cf						1
Limaria sp.						x			2
Limaria n. sp.		x							1
Limatula sp.			x						1
Pycnodonte heermanni (Conrad)				x		x			1, 2
Hyotissa hyotis Linnaeus [=*Ostrea fisheri* Dall]						x			2
Undulostrea megedon (Hanley)			x			x	x		1, 2
Myrakeena angelica (Rocheburne)		x	x	x		x			1, 2
M. angermanni (Hertlein and Jordan)	x								1
Saccostrea palmeri Carpenter						x			2
Crassostrea columbiensis (Hadley) [=*Ostrea corteziensis* Hertlein]						x			2
"*O*". *iridescens* Hanley						x	x		2
Dendostrea folium (Linnaeus)		x	x			aff			1, 2
D.? vespertina (Conrad)	x	x	x	x	x	x	x		1, 2

TAXA	OCCURRENCE								REFERENCE
	Riverside County					Imperial County			
	LC	• SC •		GH	WP				
		L	B			L	B	U	
Lucina (Lucinisca) nuttalli Conrad			x						1
L. (Pleurolucina) n. sp.		x							1
Callucina quincula Olsson			x						1
Codakia distinguenda (Tryon)						x		x	UCMP, 5
Ctena n. sp.			x						1
Parvilucina mazatlanica Carpenter			x						1
Pegophysema edentuloides (Verrill)		cf	cf			x			1, p.o.
Divalinga eburnea (Reeve)			x			x			1, 5
Miltha xantusi (Dall)								x	5
Timothynus n. sp.			x						1
Chama buddiana C.B. Adams					cf				1
C. corallina Olsson			x						1
C. frondosa Broderip								x	5
Arcinella californica (Dall)						x		x	UCMP, 5
Cardites crassicostata (Sowerby)		x							1
C. (Strophocardia) megastropha (Gray)						x			UCMP
Eucrassatella digueti (Lamy)						x			2
E. subgibbosus (Hanna)						x			2
E. n. sp.		x	x						1
Crassinella pacifica mexicana Pilsbry and Lowe			x						1
C. virians (Carpenter)					cf				1
Papyridea crockeri (Strong and Hertlein)			cf						1
Americardia guanacastensis (Hertlein and Strong)		x							1
A. n. sp.			x						1
Trigoniocardia n. sp.		x	x						1
Lophocardium gurabicum (Maury)			x						1
Nemocardium (Keenaea) n. sp.		x	x						1
Leavicardium elenense (Sowerby)		x	x						1
Tellina (Angulus) coani Keen			cf						1
T. (Phyllodina) pristiphora Dall			x						1
Macoma (Psammacoma) siliqua C.B. Adams			x						1
Florimetis obesa (Deshayes)								x	5
Semele sayi Toula			x						1
S. formosa Sowerby			x						1
S. n. sp.?			x						1
Solecurtus borggii gatunensis Toula	cf								1
S. n. sp.?			x						1
Tagelus californianus Conrad								x	5
T. (Mesopleura) peruvianus Pilsbry and Olsson			cf						1
Ventricolaria n. sp.		x							1
Gouldia california Dall			x						1
Megapitaria squalida (Sowerby)			cf			x			1
Pitar (Pitarella) n. sp.			x						1
Dosinia dunkeri Philippi								x	5
?*Dosinia* sp.		x							1
Cyclinella cyclica (Guppy)			x						1
Chione (Lirophora) hannai Parker			x						1
Corbula (Bicorbula?) n. sp.			x						1
C. (Caryocorbula) n. sp.			x						1
C. (C.) oreopendula Olsson			x						1
C. (Julicorbula) aequivalvis fossilis Pilsbry		x	x		x				1
C. (Varicorbula) speciosa Reeve			x						1
C. (V.) n. sp.			x						1
Panopea generosa Gould								x	5
P. n. sp.?		x							1
Cyrtopleura (Scobinopholas) costata Linnaeus					x			x	1, 9
Pholadopsis pectinata Conrad			x						1
Pholadomya candida dalli Olsson			x						1
Cyathodonta undulata Conrad								x	5
Cardiomya n. sp.?			x						1
Ventricordia n. sp.			x						1
Gastropoda:									
"*Acmaea*" sp.		x							po. 7
Haliotis (Padollus) pourtalesii Dall		x							3
Hemitoma (Montfortia) emarginata Blainville			x						3

TAXA	OCCURRENCE								REFERENCE
	Riverside County					Imperial County			
	LC	• SC •		GH	WP				
		L	B			L	B	U	
Rimula cancellata Schremp			x						3
Diodora alta (Adams)						x			2
D. cayenensis (Lamarck)			x						3
D. sp.			x						3
Fissurella sp.						x			2
Mirachelus imperialis Schremp			x						3
Calliostoma bonita Strong, Hertlein and Hanna						cf			2
C. olssoni Maury			x						3
C. sp.						x			2
Tegula (Agathistoma) mariana (Dall)						x			2
Homalopoma (Leptothyropsis) maiqueutiana (Weisbord)			x x						3
Arene stephensoni Schremp			x						3
Turbo (Callopoma) sp.						x			2
T. (Senectus) mounti Schremp			x						3
T. (Taeniaturbo) magnificum						cf			2
Nerita (Ritena) scabricostata Lamarck						x			2
N. (Theliostyla) funiculata Menke						x			2
Littorina varia Sowerby						x			2
Rissoina n. sp.			x						4
Architectonica nobilis Roding						x			2, 4
Heliacus rotundata (Gabb)			x						4
Turritella goniostoma Valenciemes						x			2
T. imperialis Hanna		x	x			x	x		2, 3, 4
T. sp.						x	x		2
Vermicularia pellucida eburnea Reeve						x			2
Modulus catenulatus (Philippi)						x			2
M. modulus Linnaeus			x						4
M. unidens Lister								x	5
Cerithium (Thericium) uncinatum (Gmelin)			x						4
Liocerithium judithae Keen						x			2
Cerithiopsis n. sp.			x						4
Cerithidae ineisum Sowerby								x	5
C. mazatlanica Carpenter						aff			2
Selia n. sp.			x						4
Alabina curta Woodring			x						4
Strombus gracilior Sowerby						x			2
S. (Lentigo) granulatus Swainson						x			2
S. (L.) obliteratus Hanna						x			2
S. (L.) n. sp.						x			2
S. (Tricornis) galeatus Swainson						x			2
Epitonium efferum Bramkamp *in* Durham			x						4
Niso n. sp.			x						4
Hipponis panamensis C.B. Adams						x			2
Cheilea equestris (Linnaeus)						x			2
Crepidula onyx Sowerby						x			2
Crucibulum spinosum (Sowerby)						x			2
C. scutellatum (Wood)						x			2
Natica chemnitzii Pfeiffer						x			2
N. unifasciata Lamarck						x			2
Polinices bifasciatus (Griffith and Pidgeon)						?			2
P. recluzianus Deshayes						x			2
P. uber (Valenciennes)			x			x			po, 2
Cypraea (Macrocypraea) cervinetta Kiener						x			2
C. (Muracypraea) amandusi Hertlein and Jordan						x			2
C. (M.) n. sp.						x			2
C. (Zonaria) sp.						x			2
Trivia n. sp.			x						4
Malea ringens (Swainson)		x				x			2, 4
M. ringens mareana Weisbord						x			2
Cassis subtuberosa Hanna						x			2
Ficus ventricosa (Sowerby)		cf				x			2, 4
Distorsio (Rhysema) constricta (Broderip)						x			2
Columbaria procera (Sowerby)						?			2
Murex sp.			x						2

TAXA	OCCURRENCE								REFERENCE
	Riverside County					Imperial County			
	LC	• SC •		GH	WP	L	B	U	
		L	B						
Hexaplex brassica (Lamarck)						x			2
H. erythrostomus (Swainson)						x			2
Eupleura muriciformis (Broderip)					x				UCR
Solenosteira anomala (Reeve)						x			2
Nassarius sp.					x				UCR, UCMP
Strombina solidula (Reeve)						x			2
S. n. sp.			x						4
Melongena petula (Broderip and Sowerby)						x			2
Fasciolaria (Pleuroploca) princeps Sowerby						x			2
Latirus concentricus (Reeve)						x			2
Leucozonia cerata (Wood)						x			2
Oliva spicata (Rőding)						x			2
Olivella gracilis (Broderip and Sowerby)						x			2
Vasum pufferi Emerson						x			2
Mitra (Strigatella?) crenata (Broderip)						cf			2
Subcancilla longa Gabb						aff			2
S. sulcata (Swainson *in* Sowerby)						x			2
Cancellaria cornadosensis Durham						x			2
C. obessa Sowerby						x			2
C. urceolata Hinds						x			2
C. sp.						x			2
C. (Eucila) cassidiformis Sowerby						x			2
Conus durhami Hanna and Strong						x			8
C. gladiator Broderip						x			2
C. (Asprella) arcuatus Broderip and Sowerby						cf			2
C. (Chelyconus) californicus Reeve *ex* Hinds, MS						x			2
C. (Leptoconus) gradatus Wood						aff			2
C. (L.) bramkampi Hanna and Strong						x			2
C. (L.) multiliratus walli Mansfield			x						4
C. (L.) regularis Sowerby						x			2
C. (Lithoconus) fergusoni Sowerby						x			2
C. (L.) n. sp.		x							4
C. (Ximeniconus) planiliratus Sowerby						x			2
Terebra dislocata (Say)						x			2
T. elata Hinds						x			2
T. protexta Conrad								x	5
T. robusta Hinds						x			2
T. sp.						x			2
T. (Strioterebrum) gausapata Brown and Pilsbry			x					x	4, 5
T. (S.) wolfgangi Toula								x	5
Syntomodrillia n. sp.			x						5
Agladrillia n. sp.			x						5
Polystira oxytropsis (Sowerby)						x			2
P. sp.			x						5
Crassipira n. sp.			x						5
Carinodrilla sp.			x						5
Knefastia olivacea (Sowerby)						cf			2
K. sp.						x			2
Pyramidella n. sp.			x						5
Odostomia (Chrysallida) n. sp.			x						5
O. (Menestho) n. sp.			x						5
O. (Miralda) n. sp.			x						5
"*Odostomia*" n. sp.			x						5
Turbonilla (Chemnitzia) n. sp.			x						5
T. (Pyrgiscus) n. sp.			x						5
"*Turbonilla*" sp.			x						5
Bulla punctulata Adams *in* Sowerby						x			2
B. striatus (Bruguiere)						x			2
Acteocina n. sp.			x						4
Scaphopoda									
Dentalium sp.			x						po

TAPHONOMY AND PALEOECOLOGY OF TIDAL FLAT MOLLUSCS, BAHIA CHOLLA, SONORA, MEXICO

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Species of the molluscan fauna of the northern Gulf of California exhibit distinct zonation across an extensive tidal flat at Bahía Cholla (Sonora, Mexico). Species distributions are controlled by substrate, energy level, food availability, and length of submergence. Despite strong tidal currents and the effect of time-averaging, the zonation of assemblages and individual species is often reflected in the distribution of the shelly remains.

The outer sand flat, rocky flat, inner sand flat, tidal channel, and salt marsh subenvironments within Bahía Cholla can be defined by the taxonomic composition, trophic/life habit composition and taphonomic attributes of the shelly remains. Gastropods dominate on hard and firm substrates, while bivalves prevail on sandy substrates. Herbivores are most common on rocky and shelly substrates; detritus feeders occur on the firm substrates on the inner sand flat and marsh; suspension-feeders predominate in sandy and rocky bottoms. Shell abrasion, encrustation and boring decrease landward.

Fossiliferous outcrops of Pleistocene age occur along the margins of Bahia Cholla. More than 40 species of molluscs have been identified from these beds. Taxonomic, ecologic and taphonomic criteria suggest that the Pleistocene deposits accumulated in very shallow subtidal to lowermost intertidal environments. Distinctive shell beds within the Pleistocene deposits suggest periodic disturbance by storms.

THE SPECKLED SCALLOP *ARGOPECTEN CIRCULARIS* IN AGUA HEDIONDA LAGOON, CARLSBAD, SAN DIEGO COUNTY, CALIFORNIA

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From March 1984 through August 1986 a study was conducted into the growth, reproduction, and other aspects of the life history of the speckled scallop, *Argopecten circularis* (Sowerby, 1835), which until recently had been abundant in Agua Hedionda Lagoon at Carlsbad, California and closely associated with stands of eelgrass. The results of this study will be published as a Fish and Game Technical Report.

This scallop is fast growing and relatively short lived, sometimes attaining an age of 26 months. By winter, the newly settled scallops attain a length of about 40 mm. Speckled scallops are hermaphroditic, but probably do not fertilize their own eggs. Spawning was variable, occurring in the late spring of 1984 and in the summer of the following years. The 1984 spawning season was longer and very strong compared to those of 1985 and 1986. The speckled scallop has mariculture possibilities, since reproduction can be artifically induced. Differences in various aspects of the life history of the speckled scallop can be attributed to oceanic seawater temperatures. The warm El Niño water conditions of 1982-83 are probably responsible for the variable growth and spawning conditions observed during this study. Present local water conditions are too low to support large populations of the generally tropical speckled scallop.

Note: The author would appreciate any information concerning populations of this scallop along the Pacific coast of Baja California. Any historical or anecdotal information on this species would also be welcome.

THE NUDIBRANCH FAMILY ONCHIDORIDIDAE: A CLADISTIC ANALYSIS

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The nudibranch family Onchidorididae is comprised of ten genera. These genera were examined using PAUP, a computerized cladistic analysis developed by David Swofford in 1985. The resulting Wagner tree was rooted on a hypothetical *Bathydoris*- like ancestor and used *Corambe* as a sister group. The tree was utilized to examine the constancy of various groups of characters, to compare traditional generic relationships found in the literature, and to test some of my own recent decisions on species placement.

ANATOMICAL COMPARISONS OF NORTHEASTERN PACIFIC *MYSELLA* (BIVALVIA, MONTACUTIDAE)

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Several conchologically polymorphic species of northeast Pacific *Mysella* Angas, 1877, are difficult to separate by shell characters alone. The gross anatomy of seven species has been examined to provide additional characters for species identification. When coupled with shell characters, the following anatomical features prove to be useful in separating specimens into species: 1) the number of gill filaments and the relative spacing between each filament; 2) the overall size and shape of the labial palps; 3) the morphology of the labial palp sorting grooves; and 4) the morphology of the anterior and posterior adductor muscles.

MOLLUSCAN AQUACULTURE SYMPOSIUM INTRODUCTORY REMARKS

David L. Leighton
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Department of Natural Science
San Diego State University

Molluscs contribute substantially to the world's marine harvests. Cultivation of bivalves and gastropods for seafood and the pearl/shell industries is estimated to be in excess of four million metric tons per year, 5% of the annual global fisheries catch. In Japan, marine aquaculture supplies over 40% of the domestic seafood production.

In this era of rapid scientific advance, aquaculture technology is improving efficiencies of sea farming and extending the potential for controlled production of molluscs to include more candidates each year. This symposium is most fortunate to have participants representing both the areas of established mariculture crop cultivation and the new biotechnological research which promises to revolutionize this increasingly important field.

We'll move from some promising developments for culture of the rock scallop to an introduction to the major mussel culture operations in Europe and the fascinating subject, mass rearing of giant clams in the tropics. Then we'll hear how early cell division can be restrained to produce polyploid oysters and clams with lower "reproductive drain" on growth, and about the recent biochemical and genetic engineering studies at the University of California, Santa Barbara, which are leading to more effective culture of molluscs. Finally, we'll learn how some locally centered research is facilitating development of abalone mariculture.

STUDIES LEADING TO COMMERCIALIZATION OF ROCK SCALLOP CULTURE

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San Diego State University

The Pacific North American purple-hinge rock scallop, *Crassadoma giganteus* (Gray), commonly known also as *Hinnites multirugosus* Gale, 1925, has long been popular among sport divers in California for its highly flavorful adductor muscle. This pectinid bivalve cements to firm natural and artifical substrates after completion of byssal juvenile stages at an age of approximately six months (1.5-2.5 cm). While adults exceeding 20 cm shell diameter are often found, sizes fully appropriate for market (10-13 cm) are producible by aquaculture in a two and one-half year period (Leighton and Phleger, 1977). It is the cementing habit which together with a high market value and relatively rapid growth rate, has special attraction to aquaculture. Scallops may be caused to cement to specially designed grow-out substrates at optimal densities and spatial distribution to allow maximum growth with minimal competition through crowding (Leighton, 1985).

Research to explore the aquaculture potential of the purple-hinge rock scallop began in San Diego in 1972 and soon gained support through the University of California Sea Grant program. Participating staff and students from San Diego State University concentrated efforts on studies of the biology of *Crassadoma* pertinent to aquaculture (Leighton, 1979). Principal areas of investigation were natural reproductive cycles, spawn induction, larval culture, juvenile and adult rearing systems, growth under a broad range of environmental conditions in bay and ocean near San Diego, chemical constitution of adductor muscle and marketability (by flavor profile analysis), broodstock maintenance, and an alternative to hatchery production of seed, the collection of juvenile scallops from natural plankton using artificial "spat traps" (Leighton and Phleger, 1981, Phleger and Leighton, 1986, Leighton, 1987).

At the present time but one aquaculture operation in California is marketing *Crassadoma* (Johnson Oyster Co., Drakes Estero), but interest is mounting as sources for juvenile rock scallops are being expanded. It is anticipated that this remarkable bivalve will find wide development as a principal aquaculture crop in temperate bays and oceans in many parts of the world.

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INDUCED TRIPLOIDY: A GENETICALLY MEDIATED IMPROVEMENT IN THE PHYSIOLOGICAL ENERGETICS OF CULTURED SHELLFISH

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Chromosome set manipulation involves the retention or selective exclusion of entire haploid quanta of chromosomes. Specifically, induced triploid shellfish exhibit profoundly altered physiology as evidenced by type and degree of gametogenesis, growth during the reproductive period, nutrient storage and utilization, and even sex ratio. However, these changes are not genetic so much as genetically mediated alterations in physiology because of reproductive sterility. Induced triploidy is therefore more akin to the benefits derived from improved culture conditions than it is related to genetic improvement. Theoretically, triploids can be produced for any species in selected or wild stocks in order to improve performance. Like any tool, triploidy is suitable in some situations, and not in others. Suitable situations are those in which reproductive effort substantially reduces or interferes with desired production characteristics of cultured bivalves. Where reproductive effort does not interfere, triploids are more or less useless.

For research purposes, triploids may be more universally applied as an experimental paradigm for the study of sex determination or reproductive physiology. For example, triploid *Mya arenaria* are all female suggesting an altered sex determining mechanism, possibly of the X:autosomal balance nature. Similarly, decreased reproductive effort in triploids, like *Crassostrea gigas,* effectively uncouples reproductive from somatic physiology during the reproductive season. Aspects of normal reproductive physiology of diploids may be gleaned from analysis of abnormalities in triploids.

MARICULTURE OF GIANT CLAMS

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The importance of giant clams (family Tridacnidae) as a seafood resource in the Indo-Pacific has led to the development of mariculture programs in a number of locations during the last 10 years. This presentation will be a review of current mariculture-oriented research directed toward understanding the basic biology of these bivalves (including their associated symbiotic algae, "zooxanthellae," and larval biology. A synthesis of this information is being applied to refinements in culture technology and to effective design and management strategies for giant clam hatcheries on an increasing number of South Pacific islands.

BIOCHEMICAL AND GENETIC ENGINEERING IN MOLLUSC CULTURE

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Our research efforts have focused on the development of genetic and biochemical methods to improve control over the biological processes which intrinsically limit the efficiency and yield of cultivation of economically important molluscs. Although work carried out in our laboratory has mainly been with the Pacific red abalone, *Haliotis rufescens,* the results have proven widely applicable to increasing our understanding of similar processes in other molluscan species. Our approach has been to identify the underlying mechanisms which naturally control the critical processes of reproduction, larval development, larval settlement and metamorphosis, growth, and the survival and resistance of the cultivars.

Simple, inexpensive methods have been developed as a result of this research which allow for: controlled spawning of adult abalone, using hydrogen peroxide (H_2O_2) to produce millions of gametes competent for fertilization; successful rearing of larvae using UV-sterilized, micron-filtered seawater and antibiotics to control possible microbial infection, and controlled temperature conditions optimized for normal larval development; induction of larval attachment to surfaces and subsequent metamorphosis to the juvenile stage by exposing competent larvae to the neurotransmitter, gamma-aminobutyric acid (GABA); and the development of genetic engineering techniques to search for a suitable enhancer of early growth of newly settled juveniles. Our current understanding of the biological mechanisms which control these critical processes of reproduction and development of economically important marine resources will be discussed.

ABALONE MARICULTURE IN CALIFORNIA AND RELATED SAN DIEGO-BASED RESEARCH

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Brief History of Abalone Mariculture in California

Commercial interest in abalone culture arose in the early 1960s as Pacific Mariculture, Pigeon Point (B. Owen, B. Budge and C. Black), successfully reared juvenile red abalone, *Haliotis rufescens* Swainson, 1822, from laboratory-produced eggs. Relying on "spontaneous mass spawnings," fertilized eggs were recovered from tanks holding several species of abalones. Many resulting larvae proved to be hybrids (Owen et al., 1971). Owen and

Meyer (1972) subsequently controlled fertilizations to yield hybrids of known parentage. However, as no immediate market for seed abalone existed at that time, attention of Pacific Mariculture became directed to production of oyster spat. No further abalone culture was done.

The abalone farm of California Marine Associates was started at Cayucos in 1967 (H. Staton, D. Leighton and J. Perkins). Effective methods for culture of red abalone were developed and by 1970, thousands of young occupied hatchery tanks. The company name was changed after 1977 (to Estero Bay Mariculture) and again, following a change in personnel, to Ab Farm, Inc., in 1985. Using concrete raceways for grow-out, red abalone are reared to 5-6 cm in slightly over two years. Crops are sold to local restaurants and also to the "sushi market." In 1986, sales of 180,000 young abalone returned a gross of $450,000 (F. Oakes, pers. comm.).

Ab Lab, Port Hueneme (J. McMullen), was founded in 1971. At that facility red abalone are reared from 1 cm seed to marketable "sushi size" young adults (4-5 cm) in mesh-ended plastic drums immersed in the sea at the entrance to Port Hueneme Harbor. Production in 1986 was close to that reported for Ab Farm, Inc. (J. McMullen, pers. comm.).

Advances made by these two groups are commendable. Each has developed its own practices based on information from early reports (e.g., Loosanoff and Davis, 1963, and Ino, 1952) for larval culture and rearing young juveniles. Refinements in the "art" of abalone culture have allowed major advances in control of early survival and growth. These methods have been hard-won, developed largely empirically, and are consequently regarded as proprietary and closely guarded. Perhaps the most significant extrinsic advance was afforded by the finding (Kikuchi and Uki, 1974) that gravid abalones may be induced to spawn when held in seawater exposed to short wave-length (germicidal, 254 nm) ultraviolet light. This discovery led to the observation by Morse (1977) that hydrogen peroxide through initiation of prostaglandin synthesis will cause spawning in gravid abalone. Other technological contributions (see following) have favorably impacted hatchery production.

The shellfish research laboratory of the California Department of Fish and Game began work in 1972 and has modified some of the methods used by the commercial groups (Ebert and Houk, 1984). While yet other mariculture efforts developed in the early-mid 1970s, most have selected sites for convenience rather than for high quality seawater, or have encountered other difficulties (Armbrister, 1980) and have either dissolved, moved, or are yet struggling to reach levels of significant production.

Some Aspects of Culture in the Laboratory and Hatchery

Since the report of Loosanoff and Davis (1963) it has been common practice in shellfish hatcheries to incubate larvae in highly filtered, UV-sterilized seawater with antibiotic prophylaxis (Leighton, 1977). Abalone larvae so treated and held at optimal temperatures (see following) reach settling maturity and onset of metamorphosis with virtually no mortality (Leighton, 1985). Postlarval attrition, in spite of recent claims to the contrary (cf. Morse, 1986), continues to constitute the main "bottleneck" to efficient abalone culture. Yields of juveniles after two months are usually less than 20% (unless done on a laboratory scale with intensive care) and may decline to less than 5% by four months under usual hatchery conditions (Leighton, 1985).

Larval settling and onset of metamorphosis in *H. rufescens* have been "induced" in the laboratory with low concentrations (0.1 ppm) of the neurotransmitter gamma-aminobutyric acid (GABA) and related molecules (Morese et al., 1979). Appropriately prepared (microfloral films) substrates in well-established hatcheries provide optimal conditions for settlement, metamorphosis, first feeding and growth (Ebert and Houk, 1984, Leighton, 1985). Inducer substances, likely of bacterial origin, associated with benthic microflora and often present in inocula of cultured algae (pennate diatoms, certain naked flagellates etc.) prompt nearly 100% normal settling and metamorphosis in *H. rufescens* and *H. fulgens* larvae reared at 16°C and 20°C respectively. Crustose red algae (and associated bacteria) also are effective substrates for settlement of these species. The coralline *Lithothamnion* (=*Lithothamnium*), possibly due to its epiphytic bacteria (Garland et al., 1985) provides a favored substrate for larvae of *H. ruber* Leach, 1814, as it does for *H. rufescens* and other species in California (Morse et al., 1979). While some trophic relationship exists for postlarval and early juvenile red abalone occupying *Lithothamnion* substrates, no nutritional benefit appears to exist for young red abalone larger than 5 mm (Leighton, 1968, Table XXX).

Other natural substrates are colonized as well by larvae of *H. rufescens* as primary stipe and associated haptera of *Macrocystis pyrifera* (15-25 m depth, Point Loma and La Jolla) frequently yield abundant postlarvae and young white-shelled juveniles of this species (Leighton, 1961).

Influence of Temperature on Larval Development and Early Juvenile Growth

Thermal dependence for development of larvae was defined for *Haliotis sorenseni* Bartsch, 1940 (Leighton, 1972), *H. rufescens*, *H. corrugata* Wood, 1828, and *H. fulgens* Philippi, 1845 (Leighton, 1974). Larval thermal tolerance and optima were similar for the first two species optima, 14-16°C) as for *H. cracherodii* Leach 1814 (Leighton, unpubl.). The green abalone, *H. fulgens*, exhibited tolerance to highest temperatures (optimum, 24°C) and the pink, *H. corrugata*, an intermediate range (optimum, 21°C). The thermophilic nature of the green abalone coupled with its higher juvenile growth rate prompted me to recommend it for aquaculture in thermal effluent (Leighton, 1974).

Soon interest was shown by the Southern California Edison Company and support was provided to my group (Ocean Studies Division, World Research, Inc.) to conduct a four-year research program at the SCE Redondo Beach power plant and laboratory. A mixture of effluent and ambient seawater was shown to be an entirely satisfactory medium for culture of larvae and juveniles of the green and red abalones. Growth rate of the green abalone was approximately doubled. Many tens of thousands of young abalone resulting from the research were provided to the California Department of Fish and Game for its "abalone enhancement program" (Leighton et al., 1981).

Concurrently with the thermal effluent aquaculture program, I introduced larvae, juveniles and young adults to two tropical mariculture facilities, one on the Florida Keys, and the other on Oahu, Hawaii. Feeding on tropical micro- and macroalgae at temperatures of 26-28°C, these abalone survived and grew well. Future plans include large-scale culture of the green abalone in the tropics and in both geothermal and passive solar heated systems in cooler areas.

Comparison of Field Growth and Recapture Rate for Native and Hatchery-Reared Green Abalone in the La Jolla Area

Between 1977 and 1982, 222 native juvenile green abalone were marked and 286 hatchery young planted in the shallow subtidal environment at Bird Rock, La Jolla, California. Recoveries after periods of one to 21 months averaged 23.9% for natives and 21.0% for hatchery animals (Leighton, 1985). A more recent plant of 30 hatchery-produced young adults (2-4 cm) yielded 20% recovery by superficial sampling one year later. There was no significant difference in growth rate of natives and hatchery abalone; shell length gains varied by season and were proportional to size at marking or planting. The general average monthly increment for juveniles 3-8 cm at marking was 3.5 mm. The minimum legal size for sport divers is 15.2 cm (6 in.). Green abalone at Bird Rock appear to reach that size in four years (providing two years of significant spawning activity). This stands in contrast to growth rate estimates for green abalone at San Clemente Island which indicate 10 cm is reached in four years, but 16.5 cm (6-1/2 in., commercial size minimum) is attained only after 13 years, during which time spawning may have occurred repeatedly for 10 years (Burge et al., 1975).

Success of our plants with green abalone at Bird Rock is attributed to use of PVC "temporary shelters" (Leighton, 1985) which allow mass planting of hatchery stock with negligible "planting mortality." These shelters are composed of stacked corrugated plastic sheet, material manufactured by B.F. Goodrich Co., and used commercially in secondary sewage treatment. Called "Bio-trickling filter medium," the high surface to volume ratio provides substrate for massive bacterial growth. The use of the planting habitats is demonstrated to be a highly efficient and cost-effective method (Leighton, 1985). In our studies, virtually no empty shells have been found within the first week or so following plants to suggest loss by predation; a marked contrast to the high mortality during and soon after release reported for abalone planted by hand (see Tegner and Butler, 1985). These new results are changing the outlook for successful release of hatchery-produced abalone for fishery enhancement and encouraging sea floor ranching of abalone. The Department of Fish and Game is presently testing a concrete box with spring-loaded door and magnesium wire time-release mechanism to introduce abalone to the "wilds." (K. Henderson, this WSM Meeting). The device appears somewhat cumbersome and is most questionably cost-effective.

Experiments designed to test the feasibility of seeding with late-stage abalone larvae for stock augmentation have been conducted many times in the past with the hope that the relatively inexpensively produced young would rehabilitate declining beds. Returns, however, have been difficult to assess. Often juveniles in the appropriate size class are found in subsequent surveys, but concentrations have been low. It is thought that larvae retain cilia of the velum for at least a day following settling (based on laboratory observations) and may release to redisperse from the planting site. Our methods to plant larval abalone have varied from emptying pails of 40-50,000 day six larvae into intertidal surge channels at low tide (*H. fulgens*) to placing empty beverage bottles with about 10,000 larvae in each along a transect line by diving (*H. rufescens* and *H. corrugata*). In all such plants, parallel cultures are maintained in the laboratory to show viability.

Our recent releases of hybrid *H. fulgens* x *H. rufescens* and the DF&G project with *H. corrugata* larvae (K. Henderson, this meeting) may provide insights into the problem of redispersal. Over the past five years, an ex-commercial abalone diver (D. Gilbert) has released larval abalones in appropriate environments at sea and claims increased presence of *H. sorenseni* in his leased parcel off Point Loma (pers. comm., 1987). Although the possibilities of fishery enhancement by larval release have not been explored in Japan (K. Saito, pers. comm., 1984), a successful seeding of *H. iris* Martyn, 1784, in New Zealand has recently been described (Tong et al., 1987).

Recent Research on Hybridization in *Haliotis*

Hybridization among haliotid species has yielded fertile progeny and interspecific hybrid crosses have produced three and four species complex hybrids (Owen and Meyer, 1972, Leighton and Lewis, 1982). Both the immunological studies of Meyer (1967) comparing hemocyanin affinities and the observations on fertilization success rate by Leighton and Lewis (1982) suggest genetic proximity for *H. rufescens* and *H. sorenseni* (also the most common natural hybrid in California waters; Owen et al., 1971). Thus these morphologically dissimilar species may be very young phylogenetically. Back cross and hybrid cross progeny ratios suggest simple Mendelian inheritance (Leighton and Lewis, 1982). Blocks to interspecific hybridization were found to develop rapidly in spawned eggs and appear strongest in distantly related species.

Natural hybrids are rare (0.2%, Owen et al., 1971), likely since unlike conspecific combinations, interspecific crosses require prompt fertilization (parents must be spatially close and spawnings must be synchronous). A purely artificial hybrid produced in our laboratory is *H. fulgens* ♀ *X H. sorenseni* ♂. None have been found in nature since the shallow water *H. fulgens* spawns in late spring to late fall, and *H. sorenseni,* living in deep water, spawns in winter and early spring.

The black abalone, *Haliotis cracherodii*, was regarded too distinct genetically to cross with extant sympatric species (Owen et al., 1971), but hybrids *H. fulgens* x *H. cracherodii* (Leighton and Lewis, 1982) and *H. corrugata* x *H. cracherodii* (McMullen, pers. comm.) have been produced in the laboratory. Generally shell characters of *H. cracherodii* overshadow other parental contribution with age and growth, perhaps accounting for the lack of recognition of these hybrids in nature.

In the course of these studies, juveniles of mixed parentage were reared to young adulthood. Heterosis (hybrid vigor) appeared in several crosses involving *H. fulgens.* Growth rate under aquarium conditions matched or exceeded that of the more rapidly growing parent (Leighton and Lewis, 1982).

Closed System Culture of the Green Abalone

A new approach to culture of the green abalone was tested over the past three years by Abalone Mariculture Enterprises, San Diego. A hatchery facility to which seawater is trucked regularly (about 5% of the total volume per week) and which employs extensive biological filtration, has completed its research and development phase. All life stages are cultured yielding marketable 8-10 cm young adults in a 2-3 year interval.

No longer is the operation of an abalone hatchery and grow-out system bound to location on the coast where land cost and vulnerability to a host of potential coastal disasters are major constraints. Abalone Mariculture Enterprises is now seeking capital to expand into major-scale production.

Conclusion

With current improvements in culture strategies, increased success of field introductions, and new interest in tests of grow-out approaches, abalone mariculture is well on track to become a significant area of seafood production in world mariculture.

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A REVIEW OF TAHITIAN OPISTHOBRANCHS: FAUNAL DIVERSITY AND OBSERVATIONS ON COLOR

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The fourteen Society Islands are a northwest to southeast trending chain of coral atolls and volcanic islands with fringing coral reefs located between 15° to 18° S latitude, and 147° to 155° W longitude. Similar to the Hawaiian Islands, this chain was formed by the movement of the Pacific crustal plate over a hot spot.

The opisthobranch fauna of the Society Islands is poorly known. Fewer than 45 species are reported from these islands, mainly as new species based on single or just a few specimens. Marcus & Marcus (1970) recently described 3 new species, and cited the significant occurrences of 6 other widely distributed Indo-Pacific or circumtropical species in this group of islands.

Two recent excursions to the Society Islands discovered 8 species, 5 of which are new records to the island chain, but no unnamed species. The opisthobranch fauna of the Society Islands is not expected to be very different from the 250 plus species known from the Hawaiian Islands (Gosliner, Johnson, & Bertsch, 1986).

Although preliminary studies of opisthobranch zoogeography in the Pacific Ocean traditionally show a high level of endemism within an island group, over time, taxonomic refinements and additional collecting indicate that most of the species are indigenous to a wider geographic region and range throughout the Pacific basin. Taxonomic synonymy and range extensions reduce endemism levels significantly. Endemic percentages for terrestrial and marine island animals are not equal. Although evolutionary processes are similar among terrestrial and marine animals, isolating speciating mechanisms, dispersal techniques, faunal barriers and other aspects of island biogeography are often very different.

Observations in situ on the coloration of *Phyllidia rosans* Bergh, 1873, provide evidence on the adaptive significance of nudibranch colors. Most descriptions of nudibranchs are based on living animals in aquaria or in photographs made with a bright flash. Colors are usually vivid, leading to erroneous statements that these animals have warning coloration. The vast majority of nudibranchs under rocks or at subtidal depths blend in with their surroundings. Their bright colors are apparently energetically cheap methods by which the animal blends in with its variegated and muted surroundings.

In aquaria, *Phyllidia rosans* has alternating light pink and black longitudinal lines on its dorsum. However, on the back reef at Papeete, Tahiti, in situ on a cliff face at 13 m depth, *P. rosans* appeared bluish and black, blending in with its environment. Another specimen found in the same habitat on a bluish sponge at 21 m depth appeared to my vision with the natural lighting the same color as did the sponge. The pinkish color seen on the dorsum with a flash or in an aquarium was a muted bluish tone in the natural habitat.

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OCTOPUS DIGUETI IN BAHIA CHOLLA, SONORA, MEXICO

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Movements of octopus populations remain poorly defined. Immigration rates, the effects of physical factors and differential migrations of reproductive females are inferred from trawl collections of large, commercially exploited species. In this study, the movements of *Octopus digueti* Perrier & Rochebrune, 1894, the Pacific pygmy octopus, were followed using a removal method. The species takes refuge in vacant gastropod and bivalve shells in the open, sandy habitat of Bahía Cholla in the northern Gulf of California. To monitor movements of the population and sample its members, artificial shelters were placed in the intertidal zone of the bay. Octopuses were removed from the shelters daily during spring tidal series over a one year period. Each of the 800 octopuses captured was narcotized, weighed, measured and sexed. The reproductive maturity of each was visually assessed. Of five hundred captured individuals marked before release, only 1.2% were recaptured. No evidence of territoriality or site specificity was found in *O. digueti.*

Immigration rates into the shelters were primarily dependent on moonlight, sea temperature and the reproductive status of the population. Movement into cleared shelters was significantly higher in new moon than in full moon tidal series. Periods in which a high proportion of females brooded eggs had low female capture rates and strongly male-biased sex ratios.

Female biased sex ratios occurred only in late summer, when temperatures in the intertidal zone reached 36° C and sexually mature adults disappeared from the intertidal population. Apparently, extreme heat forces females into the subtidal zone, with mature males following. Juveniles and immature females remained in the intertidal zone without suffering any apparent ill effects.

THE EASTERN PACIFIC SPECIES OF *SEMELE*

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I have conducted a review of the Recent eastern Pacific species of the bivalve genus *Semele,* which has 28 valid taxa from southern Alaska to southern Chile. My paper has many lectotype and two neotype designations, illustrates many type specimens for the first time, documents distributions and summarizes available habitat data. One new species will be described.

Some of the more significant innovations are the following: (1) The subgenera *Semele, s.s., Amphidesma,* and *Elegantula* are used along with *Semele, s.l.,* as groupings of convenience. (2) The South American *S. corrugata* (Sowerby, 1833) and *S. solida* (Gray, 1828) are closely related but distinct taxa. (3) *S. sowerbyi* Tryon, 1869, is the oldest available name for *Amphidesma punctata* Sowerby, 1833, *non* Say, 1822. (4) *S. paziana* Hertlein & Strong, 1949, and *S. simplicissima* Pilsbry & Lowe, 1932, are synonyms of *S. pallida* (Sowerby, 1833). (5) The Caribbean *S. purpurascens* (Gmelin, 1791) is not separable from the eastern Pacific *S. sparsilineata* Dall, 1915, and is the older name. (6) *S. incongrua* Carpenter, 1864, is a synonym of *S. venusta* (Reeve, 1853). (7) *S. barbarae* (Boone, 1928) is the oldest available name for *S. purpurascens* (Sowerby, 1833), *non* (Gmelin, 1791). and for *S. sowerbi* Lamy, 1913, *non* Tryon, 1869. (8) *S. junonia* Verrill, 1870, and *S. tabogensis* Pilsbry & Lowe, 1932, are synonyms of *S. rosea* (Sowerby, 1833).

MARINE BIVALVE MOLLUSCS OF THE WORLD: A COMPUTER DATABASE

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We are currently compiling data on the biogeography of Recent marine bivalve molluscan genera. To date we have information on the distribution of approximately 1200 genera among 80 worldwide regions.

The bivalve database is managed by dBase III - a popular business-oriented software package for personal computers. dBase III commands and programs permit the rapid retrieval of information on geographic distribution of families and genera, number of genera and species within regions, co-occurrences among regions, faunal lists, latitudinal distribution, longitudinal distribution, distribution within oceans, proportion of endemics within regions and other biogeographic data. These applications will be illustrated with "hands-on" demonstrations.

AN EXAMINATION OF SHELL REPAIR IN THE NORTHERN GULF OF CALIFORNIA

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Shell repair in gastropods results from damage to the aperture reflected by a scar after the snail resumes growth. Unsuccessful predation by shell-breaking predators such as crabs accounts for most instances of shell repair. Study of shell repair in Recent gastropods is a key to understanding shell repair in the fossil record and using it as an indication of predator-prey relations in the past.

Increasing shell repair frequencies through geologic time may be related to changing predation patterns through time, and the frequency of shell repair in fossil gastropods can be used as an indication of the intensity of selection for antipredatory traits.

I examined shell repair in the Recent gastropod *Cerithium stercusmuscarum* Valenciennes, 1833, from several micro-habitats within Bahía Cholla, Sonora, Mexico, in order to study the intra-specific variation in shell repair through space and to relate my findings to interpretations of increasing repair frequencies through time. These frequencies varied significantly between the micro-habitats examined; they are not caused by differences in size-frequency distributions between samples, and there is no preference for either larger or smaller snails to be attacked.

Results demonstrate significant variation in shell repair frequency through space at any one point in time, and show that this variation could blur any overall trend in shell repair frequency through time.

PHYSIOLOGY OF DORMANCY IN LAND SNAILS

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Land snails respond to dehydrating conditions by entering a state of dormancy, in which many species can survive for months or years without feeding or drinking. The ability of snails to reduce metabolic rate and water loss during dormancy prompted investigation of respiratory and acid-base physiology in *Otala lactea* (Muller). Oxygen and CO_2 tensions in the lung and hemolymph, hemolymph pH and solute composition, and rates of respiratory gas exchange were measured in active and dormant individuals.

A striking feature of respiration during dormancy is hypoventilation of the lung, i.e. reduction of lung ventilation relative to metabolic rate. The average rate of oxygen consumption of dormant *Otala* falls to about 15% that of non-dormant snails, but lung ventilation is reduced much further, to about 2% of the active level. (Barnhart, 1986).

Hypoventilation during dormancy has at least two important effects. First, CO_2 tension in the body fluids increases about 4-fold, which depresses pH (Barnhart, 1985). The accumulation of CO_2 and resulting drop in pH may be part of the physiological mechanism which controls metabolic rate during dormancy. Continuous recordings of oxygen and CO_2 exchange of dormant *Otala* show that CO_2 is accumulated and released in a cyclical pattern at intervals of 20-50 hours. Calculations of body CO_2 content based on the ratio of CO_2 release to oxygen uptake show that metabolic rate is inversely related to CO_2 content (Barnhart, 1987). In addition, exposure of active snails to exogenous CO_2 results in a rapid reduction of oxygen consumption proportional to the level of CO_2 .

A second effect of hypoventilation is to decrease the rate of respiratory evaporative water loss (evaporation from the moist lung surface). Calculations indicate that the total rate of body water loss during dormancy would increase by nearly 50% without hypoventilation (Barnhart, 1986). Thus, it appears that restriction of lung ventilation during dormancy may play a role in the control of both metabolic rate and water loss.

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ABALONE ENHANCEMENT RESEARCH BY THE CALIFORNIA DEPARTMENT OF FISH AND GAME

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Abalone enhancement research by the California Department of Fish and Game began in the 1970s. Three methods were chosen for study: transplantation of adult spawning stock, closing areas to all harvest to allow natural population recovery, and seeding areas with hatchery reared juveniles. The program was designed to evaluate the cost effectiveness of these methods and make recommendations on the most effective way to rebuild California's abalone stocks.

The most effective experimental method of enhancement is the transplantation of naturally occurring adult abalone to areas of suitable habitat. The transplanted abalone reproduce quickly and are less susceptible to predation than juveniles. Unfortunately this method is not widely applicable because few large donor stocks exist to supply transplants.

After a decade the mainland abalone closure has resulted in the partial recovery of red abalone on the Palos Verdes Peninsula. However, other species have not shown the same positive response. In light of the slow growth and limited dispersal of abalone, this method requires a long time period to rebuild severly depleted stocks.

Large numbers of small "seed" and larval abalone are now reliably produced in hatcheries. Various sizes of seed abalone have been hand planted in an appropriate habitat. This method was time consuming and the abalone were often stressed and vulnerable to predation. After experimenting with various types of artificial planting substrates, a modified concrete utility box or releasing module with collector-transporter was designed. The department is still evaluating these modules for several species.

In 1986 the Department of Fish & Game and researchers from Scripps Institution of Oceanography initiated a larval seeding experiment. These larvae can be produced at low cost and released with minimum effort. Sampling this summer (1988) will determine the survival and growth of these larvae.

ADDITIONS TO THE GASTROPTERIDAE (Gastropoda-Opisthobranchia) FROM THE TROPICAL INDO-PACIFIC AND CARIBBEAN

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Recent field expeditions to Aldabra Atoll, Papua New Guinea, the Hawaiian Islands and the Caribbean have yielded specimens of 12 species of Gastropteridae.

Four species have been described previously, but are known only from their original descriptions.

Gastropteron brunneomarginatum Carlson and Hoff, 1974, and *Sagaminopteron psychedelicum* Carlson and Hoff, 1974, were originally described from Guam, but have recently been found approximately 2000 kms south at Madang, on the north shore of Papua New Guinea. *Gastropteron ladrones* Carlson and Hoff, 1974, also known only from Guam, has now been recorded from Aldabra Atoll in the western Indian Ocean, a range extension of about 11,000 km. *Gastropteron pohnpei* Hoff and Carlson, 1983, is known from the original description from Ponape and Palau, and has since been found eastward to Oahu, Hawaii.

The remaining eight species are undescribed, including one species of *Enotepteron* and seven species of *Gastropteron.*

The morphology of these tropical taxa, which include members of the three recognized genera of the Gastropteridae, supports the maintenance of these genera. Previously, gastropterid genera have been separated largely on the basis of external morphology of the ctenidium and notal flagellum and by radular characteristics. In addition, penial morphology appears to be very useful in separating species and species groups within genera. Additional data from other species whose morphology is poorly known, are required before phylogenetic relationships within the Gastropteridae can be hypothesized.

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BIOGEOGRAPHIC AFFINITIES OF PLEISTOCENE AND RECENT GALAPAGOS MARINE MOLLUSKS

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The marine molluscan fauna of the Galapagos Islands consists principally of taxa from the Panamic Province with additional taxa characteristic of the Indo-Pacific, Californian, and Peruvian Provinces. Most fossil molluscan occurrences seem to be Pleistocene, although deposits of possible Pliocene age have been investigated (Hertlein, 1972). The taxonomic composition of the shallow water marine invertebrate fauna in general and the marine molluscan fauna in particular results from the geographic position of the archipelago with respect to oceanic currents and dispersal routes for teleplanic larvae. Taxonomic comparisons involving fossil and Holocene specimens from both recently-collected and older museum material reveal a low percentage of species-level endemism among marine mollusks (Pitt & James, 1983); a similar pattern is reported for Galapagos barnacles (Zullo, 1986). This degree of endemism is in marked contrast to the well-known terrestrial biota which exhibits a high percentage of endemism, often at the generic level. Low species-level endemism within assemblages of fossil marine mollusks suggests a Pleistocene age for sedimentary deposits consistent with radiometric ages of 3-4 Ma from basalt flows (Hickman & Lipps, 1984); biotic evolution has probably had only a short time to operate in the Galapagos (James, 1984).

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ATLANTID HETEROPODS OF HAWAIIAN WATERS

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A taxonomic review of the three families of heteropod molluscs from Hawaiian waters (Seapy, 1987) included a key and species list for the Family Atlantidae. At the time that paper was prepared, I had identified eleven species of atlantids from plankton and trawl samples collected during a number of cruises of the R/V KANA KEOKI and R/V KELA of the University of Hawaii off the leeward side of the island of Oahu. Since then three cruises of the R/V KELA have provided a wealth of additional material for taxonomic studies on the atlantids. Investigations of shell structure using the scanning electron microscope, and of eye and opercular morphology have resulted in (1) clarification of species difference in the genus *Atlanta,* (2) corrected identification of *A. plana* (previously identified as *A. gaudichaudi*, and (3) the addition of two new species (*A. oligogyra* and *A. meteori*) to the Hawaiian fauna.

The above changes and additions necessitate revision of the key that was included in Seapy (1987). The taxonomic character of eye morphology must be added to this key to facilitate the separation of two species and simplify the recognition of a third species. Richter (1974) described three basic eye types in the Atlantidae. Types A and B eyes are similar in shape, with the darkly pigmented basal part of the eye about the same width as the distal lens. Both eye types also have a clear triangular window in the pigmented basal portion (absent in the type C eye). However, the A and B eye types differ in the basal region of the eye. In the type B eye a narrow distal ring of pigmented tissue is set off from the larger basal portion by a narrow gap. Such a distal ring is lacking in the type A eye. Two pairs of species (*A. lesueuri* + *A. oligogyra* and *A. peroni* + *A. plana*) are difficult to distinguish on the basis of shell morphology, but differ in having either the A or B eye type. The shell morphologies of *A. oligogyra* and *A. lesueuri* are extremely similar, and the recent paper of Richter (1986) should be consulted for additional species differences. In the genus *Atlanta* the type C eye is unique to *A. helicinoides.* This eye type is immediately recognized by the broad basal portion of the eye, which is about twice the width of the lens. Due to its width, the lens appears to be recessed or cupped by the basal region.

Acknowledgments

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KEY TO THE ATLANTIDAE OFF HAWAII

1. a. Inner whorls of shell depressed; projecting right-handed spire lacking. Both shell and well-developed keel cartilaginous .... *Oxygyrus keraudreni*
   b. Inner whorls of shell extend outward from right side to varying degrees to form projecting spire. Although keel may be cartilaginous, shell is not 2
2. a. Prominent keel cartilaginous and transparent; keel extends to shell aperture .... *Protatlanta souleyeti*
   b. Keel not cartilaginous or transparent; keel does not extend to shell aperture .... (genus *Atlanta*) 3
3. a. Shell consists of three whorls, with the outermost whorl greatly expanded 4
   b. Shell consists of more than three whorls 5
4. a. Keel base and shell unpigmented, although inner whorls become light pink in older specimens; eyes large, type B .... *A. lesueuri*
   b. Keel base brown; shell unpigmented, although inner whorls become light violet in older specimens; eyes small, type A .... *A. oligogyra*
5. a. Spire tilted (or inclined) relative to plane of outermost shell whorl 6
   b. Spire not tilted, projecting outward at a right angle to the outermost shell whorl 7
8. a. Shell unpigmented; surface of inner whorls smooth, lacking punctate sculpture .... *A. meteori*
   b. Shell light tan; surface of inner whorls with numerous, small and regularly-spaced punctae .... *A. inclinata*
7. a. Shell compressed, width of outermost whorl about 25% of shell length; inner whorls smooth, lacking spiral sculpture 8
   b. Shell somewhat inflated, width of outermost whorl about 40% of shell length; inner whorls possess spiral sculpture developed to varied degrees 9
8. a. Sutures of inner whorls unpigmented to light pink; eye type B .... *A. peroni*
   b. Sutures of inner whorls violet; eye type a .... *A. plana*
9. a. Spire steeply sloped, projecting strongly from right side of shell 10
   b. Spire relatively flat and does not project strongly from right side of shell 11
10. a. Spire strongly turreted (spire angle about 35-45°); shell clear to light reddish-brown color .... *A. turriculata*
   b. Spire weakly turreted (spire angle about 65-75°); shell distinctive light golden brown color .... *A. fusca*
11. a. Spire of three reddish-brown whorls that project moderately; outermost whorl unpigmented .... *A. echinogyra*
   b. Spire of four whorls that do not project conspicuously beyond the plane of the outermost whorl; spire pigmentation not reddish-brown 12
12. a. Inner whorls clearly separated by incised, violet sutures; keel low; type C eye .... *A. helicinoides*
   b. Inner whorls weakly separated by shallow sutures which lack distinctive pigmentation; inner whorls further obscured by well-developed spiral sculpture; keel high; type A eye .... *A. inflata*

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SCANNING ELECTRON MICROSCOPIC STUDIES OF *CYPRAEA* RADULAE: A PROGRESS REPORT

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Radular photos have been made of more than 80% of all recognized species of *Cypraea.* Each specimen has been photographed at three different angles to show details of tooth shapes: perpendicular to ribbon (90°) as in usual optical microspy; low angle (30°) looking directly into rows of teeth; same low angle of 30°, but looking at an angle of approximately 60° to the ribbon, to show profile shapes of teeth.

These photographs show large differences from published sketches. Comparisons with Kay's 10 subgenera (Kay in Burgess, 1985) show differences that may justify subgeneric reclassification of some species, e.g., *Cypraea pulchra.*

Radulae of *Cypraea spurca, C. spurca acicularis, C. spurca atlantica,* and *C. spurca sanctaehelenae* are almost identical, and thus do not support their classification as different subspecies. Radulae of *C. astaryi* and *C. cumingii* from French Polynesia are sufficiently different to reinforce the claim that they are separate species.

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UNUSUAL *CYPRAEA* RADULAE AND RADULAE OF UNCOMMON COWRIES

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Cypraea testudinaria and *C. talpa* radulae are markedly different from all others that have been studied by scanning electron microscopy. *Cypraea testudinaria* has tiny marginal teeth, about 1/10 the length of the other teeth of the radula. *Cypraea talpa* has marginal teeth that are broader than any other teeth of the radula, and are attached to the ribbon along the entire breadth. All other observed species can be fit broadly into the 10 subgeneric categories of Kay (in Burgess, 1985). Radulae of observed rare

Cypraea classified according to Kay's groups include:

CYPRAEA SPECIES	SUBGENUS	COMMENTS
Aurantium	*Lyncina*	Very stable type of radula.
barclay	*Zonaria*	
broderipii	*Lyncina*	
fuscorubrae (Specimen identified by Burgess as *gondwanalandensis*)	*Cypraea* & *Cypraeovula*	Central tooth is like group 2; but rest of teeth are like group 1.
guttata	*Erosaria*	
katsuae	*Notocypraea*	
kingae	*Erosari*	Resembles group 3, but has no basal bract on central tooth.
leucodon	*Lyncina*	
sakauraii	*Zoila*	All teeth except central fit group 9. Central has unique shape, and very long bracts.

MOLLUSCAN FAUNA OF COCOS ISLAND, COSTA RICA, BASED ON VISITS FROM 1983-1987: PRELIMINARY REPORT

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An updated list of the molluscan fauna of Cocos Island (based on collections made between 1983 and 1987, beach combing, skin diving, SCUBA diving, dredging and netting), was presented. The list includes a total of 429 species, made up of 67 Pelecypoda, 344 Gastropoda, 8 Polyplacophora, 1 Scaphopoda and 9 Cephalopoda. The faunal affinities of this molluscan assemblage consists of 87.9% Panamic (377 spp.), 7.5% Indo-Pacific (32 spp.), 2.3% Cosmopolitan (10 spp.), 0.7% Panamic/Caribbean (3 spp.), 0.7% Caribbean/Indo-Pacific (3 spp.), 0.2% Caribbean (1 sp.), and 0.7% Panamic/Indo Pacific (3 spp.). Various aspects of specific distributions between Cocos Island, other eastern Pacific islands, and the mainland were discussed. Oceanic circulation around Cocos Island provides an explanation of the affinities and distribution patterns of this fauna, considering the surface marine currents as a temporal mechanism of dispersion.

FIELD ASPECTS OF THE SEPIOLID SQUID *ROSSIA PACIFICA* BERRY, 1911

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Introduction

Rossia pacifica Berry, 1911, is a North Pacific sepiolid squid; although it is not a teuthid, it is commonly called a squid, or in particular, the stubby squid, short squid or bob-tail squid. Common throughout the boreal North Pacific from Japan and the Aleutian Islands to southern California (Akimushkin, 1965; Roper et al, 1984), it spends daylight hours buried in the sand or mud and emerges at night to swim and/or lie in wait for prey, primarily small shrimp (Summers, 1985; Anderson, in press). General accounts of the animal can be found in popular works such as Hochberg and Fields (1980), Barr and Barr (1983), Flora and Fairbanks (1977), and Hewlett and Hewlett (1976). Most observations of the animal have been by trawl capture and in the laboratory (Brocco, 1970; Summers, 1985). Brocco studied distribution, habitat, habits, food, reproductive biology, and populations. Summers reared the squid in the laboratory through several generations and added to Brocco's life history data. Shimek (1983) reported on escape behaviors as observed by SCUBA at Friday Harbor, Washington, and Anderson (1987) reported on diver collection of the squid, its behavior and exhibition at the Seattle Aquarium (hereafter cited as S.A.).

Anderson (1987) reported that divers find the squid infrequently in water 10-30 m deep in sandy or muddy areas of central Puget Sound. S.A. divers had not reported seeing *Rossia pacifica* in the summer and only rarely during the daytime in the winter. In order to supply the S.A. with exhibit and research animals, a survey was conducted throughout one winter and spring identifying areas in Puget Sound where *Rossia pacifica* might be found reliably by divers. Water and substrate conditions, population densities, and seasonal migrations were also monitored.

Methods

Weekly night SCUBA dives were conducted during the fall, winter, and spring of 1986-1987 at sites where *Rossia pacifica* were likely to be found and accessible within two hours' travel time from Seattle. Sites were selected for moderately sloping bottoms, sand-silt substrate conditions, lack of strong currents, previous sightings, and night-time accessibility. Dives were made approximately two hours after sunset by divers who had previously seen *Rossia pacifica* and could recognize the species. Dives were confined to less than 30 m and conformed to City of Seattle diving regulations. Dives lasted approximately 40 minutes and covered nearly 100 m of bottom distance.

When *Rossia pacifica* were spotted, the depth and water temperature were noted. Some water was sampled for pH and salinity, and bottom samples were taken for sediment analysis in some areas of high squid sightings. Salininty and pH were measured at the S.A. laboratory and sediment analysis was performed by the University of Washington Oceanographic Laboratory. A comparative sediment sample from one non- *Rossia pacifica* site appeared to be clean sand.

Slope was measured in areas of high *Rossia pacifica* sightings with an elementary inclinometer. Tidal currents were recorded based on diver observations. Some *Rossia pacifica* were captured for display and holding at S.A. but most were left undisturbed. Dash Pt., Tacoma, Washington, had a high number of sightings (as high as 7 in one dive) and was selected for more intensive survey. No squid were taken from that site. Three monthly "mass" dives at this location determined population density and distribution during the spring of 1987 over a preset distance of 100 m.

Results

A total of 69 specimens of *Rossia pacifica* were observed from 28 September 1986 to 23 May 1987 during 23 dives. Squid were found at 11 sites between Seattle and Tacoma, one site on Hood Canal and one site on Burrows Bay. The central Puget Sound sites are depicted in figure 1; average bottom slope where they were found was 14%. Salinity and pH did not vary appreciably between sightings and did not differ from readings taken at S.A.; average values were 28.5% and 7.8%, respectively. Results of the sediment analysis are given in figure 2.

Average depths of *Rossia pacifica* sightings by month are shown in figure 3 along with average monthly temperatures as recorded at S.A., at 15 m depth.

At Dash Point, the site selected for a mass survey, 25 *Rossia pacifica* were found within 100 m of the shoreline by six divers in April; two were found in May and none in June.

Discussion

Rossia pacifica has been considered a rare find by S.A. divers but this survey shows that it is found at more sites, in greater numbers, and at shallower depths than previously realized. Fewer squid were seen in early summer months based on our mass survey dives at Dash Point. Summers (1985) found that adult squid mated, spawned and died in the late spring and early summer, observations corroborated by my experience at S.A. where they spawn and die in May and June. Brocco's (1970) population on the east side of Vancouver Island, Canada, spawned and died in August and September when the warming water temperature approached 11°C; he suggested that higher temperature acted as a stimulant to spawning. Correspondingly, the *Rossia pacifica* at S.A. spawn in May when the seawater temperature reaches 11°C (see figure 3). Since they have a two year life span spawning and death effectively eliminate half the population, leaving juveniles about 10 mm dorsal mantle length and eggs (Summers, 1985). Small individuals are more difficult for divers to spot.

Summers (1985) trawled *Rossia pacifica* in the summer in depths of 40-60 m and Brocco (1970) trawled them in 30-55 fathoms, depths beyond our diving range. Ronald L. Shimek, biologist and diver/photographer, has seen *Rossia pacifica* while diving in Friday Harbor Bay (Washington) in the summer but in decreased numbers (Shimek, pers. comm.), which he attributes to the spawning die-off. His is a different population than ours, and Friday Harbor Bay has lower temperatures than Puget Sound.

In this study, *Rossia pacifica* were typically found on moderately sloping bottoms (average 14°), which continued down to the cold depths of Puget Sound (>300 m), so it would not be difficult for them to move deeper. *Rossia pacifica* have been caught in shrimp trawls deeper than 80 m in Puget Sound (Daniel Doty, University of Washington, pers. comm.). Other cephalopods in the area such as *Octopus dofleini* (Wulker, 1910) make depth migrations (Mottet, 1975). Factors influencing migration may be temperature, amount of daylight, food supply, or reproductive stimuli; in this case I believe it to be temperature, as demonstrated by figure 3.

Sediment analysis shows that *Rossia pacifica* were found in muddy sand containing fine sediments and organics. We did not find any on pure mud or clean sand but rather in muddy areas somewhat protected from Puget Sound's strong tidal currents. Some *Rossia pacifica* were found in Tacoma and Seattle harbors and outside Seattle's largest pleasure boat marina, areas with polluted bottom sediments (Puget Sound Water Quality Authority, 1987). The effect on *Rossia pacifica* of being buried much of the time in these sediments is unknown; possibly the considerable mucus it secretes can protect it.

I believe estimates of the number of *Rossia pacifica* in Puget Sound have to be adjusted upwards. The squid was found at nearly all dive sites between Seattle and Tacoma, a shoreline distance of about 48 km. Twenty five *Rossia pacifica* were found within 100 m in divable depths in one limited survey, and this site was probably not unique. While extrapolation of the numbers from that limited area to the whole shoreline distance would be unwise, it can be concluded that *Rossia pacifica* is far more common than previously thought.

Acknowledgments

The following divers braved the elements and dove at night to help me look for squid this last winter: Bill Robertson, Dan and Doyla Doty, Joy Vanderwerff, Bill Bruin, Bill Englehardt, Pat McMahon, Richard Hocking, Rick Slightam, Walt Rostykus, and Jeff Christiansen. Thanks also to the Tacoma Metropolitan Park Department for letting us dive at Dash Point Park after hours, to the Seattle Aquarium graphics department for preparing figures for this paper, to Katherine Krogslund at the University of Washington Seawater Chemistry Lab for performing sediment analysis, and especially to Dr. William C. Summers at Western Washington University for encouragement and review of this manuscript.

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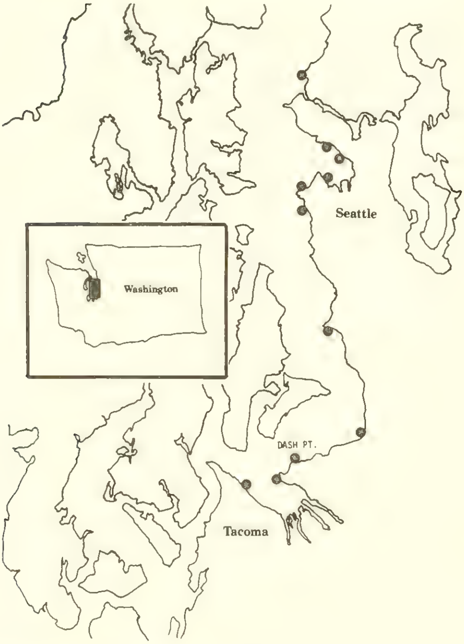

FIGURE 1. Sites in Puget Sound (Washington State) in the Seattle-Tacoma area where *Rossia pacifica* was found, 1986-1987.

	BOTTOM SAMPLES	
AVERAGE OF 3 ROSSIA SITES	SAND	86.65%
	SILT	13.35%
	%C	0.575%
	%N	0.169%
1 NON-ROSSIA SITE	SAND	96.75%
	SILT	3.25%
	%C	0.172%
	%N	0.012%

FIGURE 2. Sediment composition of *Rossia pacifica* sites, as determined by the University of Washington Oceanographic Lab (Seattle).

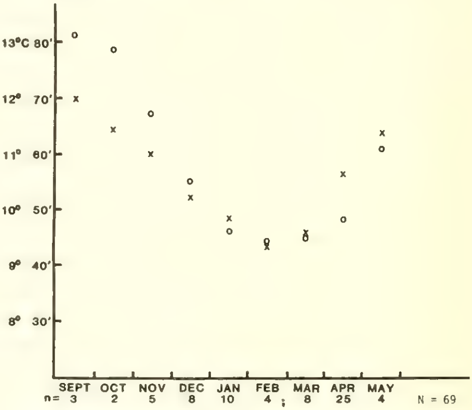

FIGURE 3. x's are the average depth per month of *Rossia pacifica* sightings in 1986-1987.

o's are the average seawater temperatures per month as measured at 15 m at the Seattle Aquarium during the same period.

SYSTEMATIC SIGNIFICANCE OF SHELL ULTRASTRUCTURE IN THE NORTH AMERICAN GENERA OF PUPILLIDAE

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A comparison of genera of the pulmonate family Pupillidae of North America, reveals some subfamilies with consistent forms of shell ultrastructure that are viewed as monophyletic and other subfamilies with diverse morphologies that are polyphyletic. The Pupillinae and the Gastrocoptinae are apparently monophyletic. Both the Vertigininae and Nesopupinae contain some genera with complex shell ultrastructure while other genera exhibit relatively simple shell ultrastructure, suggesting that neither subfamily is monophyletic. *Nearctula* Sterki, 1892, previously synonymized with *Vertigo*, is probably a valid genus. Further study is necessary in order to determine the subfamily affinities of *Nearctula* and *Sterkia*, because the genital anatomies of these two genera are unknown.

HOW DO COWRIES ENLARGE THEIR SHELLS?

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Mollusks of Cypraeacea and related Triviacea seem to have a pattern of enlargement that is unique among the gastropods. They follow a normal growth pattern from the veliger to the protoconch stage, in which the shell differs from most other gastropod protoconchs. The shell is very thin, and becomes *Bulla* shaped with less torsion than in most families. Enlargement of the shell seems to be normal for about three whorls, as shown by slides of sectioned shells of *Cypraea spadicea* Swainson, 1823, which I selected for this study. Then the shell is thickened on both sides of the aperture and denticles are added at the start of the teloconch stage which begins a unique method of further enlargement of the shell.

The shell is enlarged at regular growth periods. The mollusk goes into a safe crevice and the mantle cuts the shell for its full length just at the edge of the thickened outer lip area. The entire outer lip grows outward and around to provide room for body growth, then fills the gap with new shell material which is fused to both edges of the existing shell. The row of denticles on both sides of the aperture are dissolved away and new denticles are made. The number of denticles remains the same, but the new ones are larger and farther apart, as shown by photos of a growth series.

Several other species of cowries show the same pattern of enlargement as do some species of other families of the Cypraeacea and Triviacea, and probably the Ovulinae.

A COST-BENEFIT ANALYSIS OF MEMBERSHIP IN AGGREGATIONS OF *PLACIDA DENDRITICA* (MOLLUSCA: GASTROPODA: OPISTHOBRANCHIA: SACOGLOSSA)

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The sacoglossan *Placida dendritica* forms feeding aggregations on the green alga *Codium.* The size-frequency distribution of *Placida* aggregations was temporally and spatially constant from April to August 1986 in Oregon. The trophic implications of aggregation were examined in a series of laboratory experiments. The effect of group membership on *Placida* growth depends on the group size and composition (similar vs. dissimilar-sized animals). Members of *Placida* aggregations composed of similar-sized individuals grow faster than single animals. However, in mixed-sized aggregations, trophic benefits are not shared equally among all members. Small *Placida* always benefit from the presence of other conspecifics, where large *Placida* may or may not benefit, depending on the size of conspecifics and the species of *Codium* consumed.

SACOGLOSSAN ATTACK IS MEDIATED BY CONDITION OF THE ALGAE: PRELIMINARY RESEARCH

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Aggregations of the sacoglossan herbivore *Placida dendritica* (Mollusca: Gastropoda: Opisthobranchia: Sacoglossa) are distributed patchily within and between populations of the green alga *Codium*. Research in progress evaluates whether sacoglossan patchiness could be due to differential algal condition. During 1986, sacoglossan attack in the field study area was concentrated on *Codium* thalli on sunny, east and south-facing substrata relative to those on shady, west and north-facing surfaces. In laboratory experiments, *Placida* responds differently to *Codium* tissue subjected to different levels of two types of stress (herbivore attack and desiccation damage). A minimum threshold of stress is required to alter algal susceptibility to *Placida.* Low to moderate stress increases algal attractiveness to *Placida*, whereas high stress decreases it relative to unstressed, control thalli.

CALIFORNIA LATE CRETACEOUS DONACIFORM BIVALVES

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California donaciform bivalves of late Cretaceous age occur sporadically and locally abundantly in coarse grained sandstone; where abundant they indicate near strand-line deposition. They constitute more than 90% of the retrieved specimens from low in the Musty Buck Member of the Chico Formation on Chico Creek in Butte County in a few beds of the Great Valley series near Martinez and in Deer Valley in Contra Costa County, and in the Cabrillo Formation on Mt. Soledad, San Diego County, California. Seven species can be distinguished and allocated among two genera of Donacidae and one new genus of Mesodesmatidae.

The presence of donacids in Cretaceous rocks of California has not previously been recorded. They have been described from the Cretaceous of the Western Interior and the Gulf and Atlantic Coasts of the United States, as well as Lebanon and Argentina. The larger sized of the California donacid genera comprises two new species and resembles *Notodonax* Feruglio, 1936, from Argentina, rather than *Protodonax* Vokes, 1945, from the Western Interior, Atlantic Coast, and Lebanon. The smaller sized of the California donacid genera, which includes "*Pharella*" *alta* Gabb, 1864, and one new species, resembles *Ceroniola* Wilckens, 1904, of Maastrichtian age, from Chile. *Ceroniola* has previously been included in the Mesodesmatidae, but the California species are not mesodesmatids; their hinge is most suggestive of the Donacidae.

Only one species, *Mesodesma pacifica* Hall and Ambrose, 1916, of Miocene age, has been described from California as being a mesodesmatid. It has been reallocated to *Myadesma* Clark, 1922, a genus of uncertain affinities, but certainly not of the family Mesodesmatidae. Worldwide the family is meagerly represented in the fossil record. *Mactropsis* Conrad, 1854, from the Eocene of Alabama, although included by most workers in the Mesodesmatidae, is more closely related to the mactrids *Spisula* and *Mulinia*, and, as noted above, *Ceroniola* is probably a donacid. According to the Treatise on Invertebrate Paleontology (Keen, in Moore, 1969), *Ervilia*, which is reported from the Pleistocene, is the only other fossil mesodesmatid. Three new species from the Late Cretaceous of California have hinges that show evident relationship to *Mesodesma* and belong to a new mesodesmatid genus. Its hinge has long anterior and short posterior laterals that are striate only on the dorsal side like those of *Mesodesma*. The new genus differs in having the external ligament on nymphs, and the resilium in a more posterior position, resulting in cardinal teeth that are less crowded.

LITERATURE CITED

Moore, R.C. 1969. Treatise on Invertebrate Paleon. Part N (2): Mollusca 6: Bivalvia. Geol. Soc. America.

PHOTOGRAPH OF MEMBERS, ANNUAL MEETING

Row 1: Cynthia Trowbridge, LouElla Saul, Shi-Kuei Wu, Yvonne Allen, Katherine Stewart, Camilla Wallis.

Row 2: Margaret Mulliner, Joyce Gemmell, Bert Draper, Art Metcalf, Twila Bratcher.

Row 3: Judy Terry Smith, Forrest Poorman, Kathy Langan, Helen DuShane, Charlotte Norrid, Nancy Schmidt, Barbara Chaney, Dana Geary, Paul Scott, Michel Montoya.

Row 4: Nikki Vaughan, June King, Roland Anderson, Don Shasky, Lois Pitt, Bill Pitt, Wes Farmer, Tom Burch, Jody Woolsey, David K. Mulliner.

Row 5: John Minch, William K. Emerson, Kirstie Kaiser, Carole Hertz, Jules Hertz, Chuck Powell, Paul Skoglund, Hal Norrid, Sandra Millen, Henry Chaney, Carol Skoglund, Terry Gosliner.

Row 6: Ed Minch, George Kennedy, Gene Coan, Roy Poorman, Janet Voight, Matthew Joseph James, Karl W. Flessa, Pete Haaker, Wendy Koch, Ron Velarde, Hugh Bradner, Richard B. Saul, Robert Koch.

RECORD OF AWARDS

American Malacological Union, Pacific Division, Awards:

1960: E.P. and E.M. Chace
1963: A. Myra Keen
1964: W.O. Gregg (plus Chairman's Award to S.S. Berry)
1965: R. Stohler
1966: T. Kincaid
1967: A.G. Smith (plus Chairman's Award to J.Q. and Rose Burch)
1968: L.G. Hertlein

Western Society of Malacologists, Award of Honor:

1970: C. and J. Cate
1971: A. D'Attilio
1972: W.K. Emerson (plus President's Award to Dwight Taylor)
1973: R. Talmadge
1974: K.W. Palmer
1977: R. Stohler
1980: H. DuShane
1983: J. McLean

Western Society of Malacologists, Honorary Membership:

1973: A.M. Keen
1974: R. Stohler
1977: W.O. Gregg and E.P. Chace

ERRATUM: Please note that the correct title of the article by Paul H. Scott (1987, W.S.M., Annual Report 19: 13-14) is "A Preliminary Review of *Mysella* (Bivalvia, Montacutidae) from the Northeastern Pacific," as printed in the Table of Contents of that volume.

SUMMARY OF MINUTES EXECUTIVE BOARD MEETING

21 JUNE 1987

The meeting was called to order by President Carole Hertz at 2:33 pm. Present were C. Hertz, Matt James, Terrence Gosliner, William Pitt, Henry Chaney, Hans Bertsch, Eugene Coan, Kirstie Kaiser and guest Sandra Millen.

Secretary's Report: Kirstie Kaiser read the minutes from the 1986 Executive Board Meeting. They were approved as read.

Treasurer's Report: Hank Chaney reported that as of 21 June 1987 the Society had a balance of $5,490.72, noting that income will be augmented by additional registrants, auction proceeds and accrued interest. Expenses will include additional conference fees, banquet, and group photograph. The Society currently has 255 members which include 21 new members in 1987 and 7 new student members.

It was suggested that the institution membership list be reconsidered. E. Coan offered to study the list and make recommendations.

Nominations of Officers for 1987-1988: T. Gosliner, Chairman of the Nominating Committee, presented the following recommended slate of officers:

President	Matthew James
1st Vice President	Hans Bertsch
2nd Vice President	Roland Anderson
Secretary	Kirstie Kaiser
Treasurer	Henry Chaney
Members-at-Large	Sandra Millen, Lois Pitt

It was MSP to accept the slate of officers as presented.

Annual Report Matters: Hans Bertsch reinterated the necessity of controlling the factors of time, cost, and quality in producing the Annual Report. Editorial and printer continuity bring a certain amount of stability in producing the Annual Report. The original estimated cost for the Annual Report, volume 19, was $1800 with 30 pages; the actual cost was $2082 with a total of 40 pages.

Suggestions were made by T. Gosliner, E. Coan, C. Hertz, and H. Bertsch: Number of pages may need to be restricted; membership list may not need to be type-set again, only revised; instead of printing both the General and Executive Board meeting minutes in the Annual Report, only the Executive Board meeting minutes be included; list all past Award of Honor recipients in the next Annual Report; membership list be in reduced type to conserve space; the 40 gratis listings will be deleted from the printed membership list; that it was the member's responsibility to notify the editor not to print his/her abstract; that a program summary will not be published in lieu of an abstract submitted by the author (motion MSP); Editor Bertsch had available "Instructions for Authors" to be given to each presenter.

H. Chaney reported that the Treasurer's report will be more compact, thus taking less space next year; he also recommended that all officers' addresses be deleted as they are printed in the membership list.

Bill Pitt mentioned that the winner of the 1986 WSM Student Grant Award was Kenneth Lohmann (University of Washington), as stated in the Editor's Note (Ann. Rept. 19:31), not Ken Leonard as listed in the Minutes, p. 29.

Discussion that we ask for a voluntary donation for each extended abstract to help defray publishing costs, resulted in the following motion: MSP The editor may request a voluntary donation of $10 per page for extended abstracts or full length papers that are over one printed page. It is the editor's job to notify and use discretion in asking for these donations.

E. Coan stated that the editor has the power to regulate the cost of back issues of the Annual Report.

Student Grant: MSP that: The A. Myra Keen Student Grant will be at least $500. At an arbitrary date, set by the treasurer and student grant chairman, additional cumulative contributions will be added to this amount. Thus the total amount of the award will be set for each granting period.

Best Student Paper Award: It was discussed and agreed that only one Best Student Paper Award be given in any one year period since the title does connote a single unit. The 1986 Best Student Paper Award was awarded to Janet Voight (University of Arizona, Tucson).

Preliminary Budget for 1987-1988: Treasurer Chaney projected the total estimated operating costs for the coming year would be $2038. He noted that the estimate based on the past four years and is exclusive of any insurance costs. He also noted there will be a postage rate increase during 1988. Editor Bertsch promised to cut costs where feasible on the Annual Report and was given a budget of $2030, including postage.

Other Business: 1989 AMU Meeting: Secretary Kaiser reported on the balloting concerning the proposed 1989 combined meeting with the AMU. As of 21 June 1987, a total of 49 ballots were received, with 43 yes votes, 4 no votes, and 2 abstentions.

Life Memberships: After studying the matter, Treasurer Chaney concluded that it would not be a good idea to offer Life Memberships since it could jeopardize our income for operating costs in the future.

Award of Honor: President Hertz reported looking into the Award of Honor. She read from the by-laws concerning this award and suggested forming a committee to look into its posibilities. E. Coan suggested instead that President Hertz notify the membership of the procedure for nomination of candidates for the Award of Honor at the Annual Business Meeting.

Terms of Office of Secretary and Treasurer: President Hertz suggested we set a specific number of years to these two offices as it was quite hard on operations to have these offices filled anew each year. After considerable discussion it was decided not to set a time limit as it may discourage prospective members from taking the responsibility of these particular offices.

There being no further business, the meeting was adjourned at 5:45 pm. The full minutes of the meeting were respectfully submitted by Kirstie K. Kaiser, Secretary, and approved by Carole M. Hertz, President.

SUMMARY OF MINUTES ANNUAL BUSINESS MEETING 24 JUNE 1987

The meeting was called to order by President Carole Hertz at 3:55 pm.

Present: 32 members

Treasurer's Report: Treasurer Chaney reported the status of both the money and membership for the period of 15 October 1986 to 20 June 1987. Chaney also reported the auction proceeds totaled $1065.

Election of Officers: Terrence Gosliner, Chairman of the Nominating Committee, presented the recommended slate of candidates for office, and it was MSP to accept them as presented, by acclamation.

Committee Appointments: President Hertz announced the following appointments:

Parliamentarian	Eugene Coan
Historian	Barbara Chaney

Standing Committees:

Nominating	Carole Hertz (ex officio Chair) Terrence Gosliner (ex officio)
Audit	Bob Koch (Chair) Hal Norrid Paul Skoglund

Ad Hoc Committees:

Student Grant	Vida Kenk (Chair) Eugene Coan Terrence Gosliner James Nybakken Judith Terry Smith
Student Best Paper Award (1987) Annual Meeting:	Terrence Gosliner Matthew James

Student Best Paper Award: Terry Gosliner announced that Cynthia Trowbridge (Oregon State University) was the winner of this award for 1987.

New Business: 1988 WSM Annual Meeting: First Vice President Matt James announced that next year's annual meeting will be held in northern California on the campus of Sonoma State University. In order not to conflict with other major malacological meetings or functions at Sonoma State University, the dates are set for Sunday 17 July, through Thursday 21 July 1988. James reports that the Mediterranean style dorms are comfortable and that the technical sessions will be held in Darwin Hall. Two symposia are planned and are provisionally titled: Recent and past Molluscan Fauna of the Galapagos Islands, and Pelagic Molluscs of the Pacific.

Bill Pitt thanked all who helped to make the auction successful. George Kennedy reported a total of $69.55 from the sale of reprints.

E. Coan announced Victoria Fabray as the recipient of the 1987 A. Myra Keen Student Grant Award for her work on the role of pteropods.

Secretary Kaiser read a letter of thanks from Kenneth Lohmann who was the recipient of the 1986 WSM Student Grant Award.

President Hertz read the rules applicable to the Award of Honor from the by-laws. She also reviewed all previous award recipients and asked all in attendance to think of possible candidates.

Henry Chaney commended Dr. Harald A. Rehder and proposed that the WSM unanimously pass a resolution honoring Dr. Harald A. Rehder, Curator Emeritus, Smithsonian Institution, on his 80th birthday, acknowledging him as the Dean of American Malacology. MSP.

President Hertz asked E. Coan to read the resolution passed in the Board Meeting concerning contributions to the Student Grant Fund. There was considerable discussion among the Treasurer, Bill Pitt, and several members as to what the auction money supports, and what the annual dues support. T. Gosliner suggested the amount for the Student Grant be kept significant because of high student costs. It was MSP that: The A. Myra Keen Student Grant will be at least $500. At an arbitrary date, set by the Treasurer and Student Grant Chairman, additional cumulative contributions will be added to this amount. Thus, the total amount of the award will be set for each granting period.

The discussion of funds questioned whether our present dues were adequate to support the Annual Report, student grants, etc. Treasurer Chaney concluded that the present dues do not fully cover the cost of the Annual Report and that we have been slowly losing money over the past years from this erosion. Chaney suggested that we consider raising the dues in the near future. Gosliner suggested that the President ask the Treasurer to study the matter and report back.

Dr. Don Shasky made a motion to send a letter from the WSM to the Director of the San Diego Museum of Natural History to voice our displeasure over allocation of the Joshua L. Baily Fund revenue to support non-molluscan research in the Department of Marine Invertebrates.

Considerable discussion ensued over the situation at the San Diego Museum of Natural History concerning the Department of Malacology. It was MSP to send a letter stating: The Western Society of Malacologists regrets the decision of the San Diego Museum of Natural History to terminate their long standing program of molluscan research by allocating the Joshua L. Baily Fund revenue to support non-molluscan research in the Department of Marine Invertebrates.

E. Coan stated that the meeting of the Congress of Latin American Malacologists will be held in February 1988. He also urged malacologists to support the California Malacolozoological Society by subscribing to The Veliger.

There being no further business the meeting was adjourned at 4:30 pm. The complete minutes were respectfully submitted by Kirstie K. Kaiser, Secretary, and approved by Carole M. Hertz, President.

WESTERN SOCIETY OF MALACOLOGISTS TREASURER'S REPORT

1 October 1986 - 30 September 1987

INCOME

Membership dues	$ 1,832.00	
Student Grant 1987 Donations	301.00	
Interest on Savings Account	135.55	
Auction and Reprint Proceeds	1,072.00	
Conference fees	9,629.41	
TOTAL INCOME during period		$12,969.96

EXPENSES

Annual Report	$ 2,082.32	
Memberships and Fees	37.00	
Reimbursements to Officers	597.00	
Reimbursement to AMU (1986 Meeting)	400.00	
Student Grant	500.00	
Conference charges	8,675.08	
TOTAL EXPENSES during period		$12,490.17
NET GAIN for period		$ 479.79
Beginning balance (1 October 1986)		$ 4,714.86
NET WORTH on 1 October 1987		$ 5,194.65

NOTES FROM THE WESTERN SOCIETY OF MALACOLOGISTS STUDENT GRANT COMMITTEE

The Western Society of Malacologists has awarded nine student grants since it began the program in 1973. In the spring of 1987 more than 300 announcements were sent to marine laboratories and university departments nationwide; 24 applications were received from master and doctoral degree candidates representing 19 institutions and 3 foreign countries.

Student Grant Committee members met in June to discuss the proposals and select a winner whose research proposal is strong, interesting, well organized, clearly stated, and realistic in terms of its budget and time. As always, several proposals merited the award and would have benefited from a larger stipend. The 1987 winner is **Victoria J. Fabray**, a student in the Department of Biological Sciences at the University of California, Santa Barbara; her research concerns individual growth rates and population production of pteropods (Opisthobranchia, Thecosomata) and their significance as a source of calcium carbonate in the oceans.

As an aid to unsuccessful applicants, the Student Grant Committee Chairman, **Vida Kenk,** includes in the letters of notification the committee's suggestions for alternate sources of funding or improvements in designing or formulating their proposals. In keeping with the Society's committment of encouraging students, we invite them to attend meetings and keep us up to date on their research.

We are pleased to mention that the 1985 grant winner, **Kenneth J. Lohmann,** of the University of Washington, has published his results in Science, vol. 235, p. 331-334 (16 January, 1987), citing the Western Society of Malacologists in the acknowledgments. His article, coauthored with A.O. Dennis Willows, is "Lunar-modulated geomagnetic orientation by a marine mollusk."

The Student Grant Committee notes that an increasing number of outstanding applications is submitted each time we award a WSM Student Grant. We are exploring ways to increase the amount of money (currently $500.00) by having the 1989 grant honor one of our members and malacological mentors, **Dr. A. Myra Keen,** who was especially interested in encouraging students. We hope all members will support this Society project by making voluntary donations to the student grant fund at the time they pay their dues.

The Student Grant Committee members are:

Vida Kenk, Chairman, 1979 to present
Eugene Coan
James Nybakken
Judith Terry Smith
Terrence Gosliner

Former committee members are:

James Carlton, Chairman, 1972-1978
Carole Hickman
Barry Roth
Peter Rodda

WESTERN SOCIETY OF MALACOLOGISTS STUDENT GRANT WINNERS 1972 TO PRESENT

1972 **Carl A. Stiefbold,** Portland State University
The role of neurosecretion in the transformation of the rock-boring clam *Penitella penita* from the working-asexual to the resting-sexual form.

1973 **Carol N. Hopper,** University of Hawaii
The effects of particle size and concentration on the feeding behavior of the vermetid *Petaloconchus keenae* Hadfield and Kay, 1972.

1975 **Judith A. Christensen,** University of Arizona
Electrophoresis studies of selected species of the genus *Rabdotus*

1977 **Janice E. Thompson,** Scripps Institution of Oceanography
On the nature of the food of *Diodora aspera* (Gastropoda) and its commensal *Arctonoe vittata* (Polychaeta)

1979 **Esther M. Leise,** University of Washington
The polyplacophoran girdle: its structure and function

1981 **Douglas J. Eernisse,** Center for Coastal Marine Studies, University of California Santa Cruz
A comparison of reproductive and electrophoretic patterns within the chiton genus *Cyanoplax*

1983 **David J. Myers,** California State University Fullerton
Trophic role of *Astraea undosa*

1985 **Kenneth J. Lohmann,** University of Washington
Geomagnetic orientation by a marine mollusc

1987 **Victoria J. Fabray,** University of California Santa Barbara
Contribution of pteropod molluscs to the calcium carbonate cycle in the Pacific Ocean

1987-1988
WESTERN SOCIETY OF MALACOLOGISTS OFFICERS AND EXECUTIVE BOARD

President	Matthew J. James
First Vice President	Hans Bertsch
Second Vice President	Roland C. Anderson
Secretary	Kirstie L. Kaiser
Treasurer	Henry Chaney
Members-at-Large	Sandra Millen and Lois Pitt
Past Presidents	Carole M. Hertz, Terrence M. Gosliner and William D. Pitt

SERVICE POSITIONS AND COMMITTEES

Editor	Hans Bertsch
Mentor Parliamentarian	Eugene V. Coan
Historian	Barbara K. Chaney
Nominating Committee	Carole M. Hertz and Terrence Gosliner
Audit Committee	Robert Koch, Hal Norrid, and Paul Skoglund
Student Grant Committee	Vida C. Kenk, Eugene Coan, James Nybakken, Terrence Gosliner, and Judith Terry Smith
Student Best Paper Award, 1987 Annual Meeting	Terrence Gosliner and Matthew J. James
Liaison for 1989 Joint WSM/AMU Meeting	Terrence Gosliner, F.G. Hochberg, and George L. Kennedy

ANNOUNCEMENTS OF FUTURE MEETINGS

The 21st Annual Meeting of the Western Society of Malacologists will be held 17-21 July 1988, in Darwin Hall on the campus of Sonoma State University. Planned symposia will cover the biogeography and evolution of the molluscan fauna of the Galapagos Islands, and plant-herbivore interactions.

There will be a field trip to study Holocene and Pliocene molluscs in Sonoma County, with stops at the exposed rocky outer coast at Bodega Head, the protected sand-mud flats of Bodega Harbor, and the Pliocene Wilson Grove Formation. Included on this excursion are tours of the Bodega Marine Laboratory and the Korbel Champagne Cellars.

For further information, please contact Dr. Matthew J. James, president Western Society of Malacologists, Dept. of Geology, Sonoma State University, Rohnert Part, CA 94928; phone (707) 664-2301/2334.

The 22nd Annual Meeting of the Western Society of Malacologists will be a joint meeting with the American Malacological Union, under the joint chairmanship of Dr. Hans Bertsch and Dr. James McLean. This meeting will be held on the campus of the University of Southern California, from 25-30 June 1989.

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INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8½" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in this volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Research Associate, Dept. Invertebrate Zoology, Los Angeles County Natural History Museum, 900 Exposition Blvd., Los Angeles, California 90007.

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EL NINO 1982-1983 AND NEW RECORDS OF INDO—WEST PACIFIC FISHES AT THE GALAPAGOS

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Following El Niño 1982-1983, five species of Indo-West Pacific fishes were recorded for the first time in the East Pacific at the Galápagos. These records indicate the importance of the El Niño phenomenon as an eastward transport mechanism across the equatorial Pacific.

Observations in the Galápagos Archipelago during and subsequent to the 1982-1983 El Niño event showed an increase in the population size of 21 different tropical and subtropical fish species. One endemic species of damselfish, *Azurina eupalama* (Pomacentridae) disappeared during the event and has not been recorded since.

Five species of fish were recorded in the East Pacific for the first time at the Galápagos since the 1982-1983 warm water event. The arrival of adults of these Indo-Pacific forms may well be attributed to the El Niño.

These are: *Chaetodon auriga, Chaetodon kleini, Chaetodon lunula, Canthigaster janthinoptera, and Canthigaster valentinii.*

The nearest shallow water marine habitats are 7,000 kilometers west of the archipelago at the Christmas Island Group. The Marshall-Gilbert Islands are 11,000 kilometers from the Galápagos. These two archipelagos are the two most likely sources of tropical reef fishes being carried to the Galápagos from the west.

Hypothesis: The invasion into the East Pacific of warm waters associated with the El Niño phenomenon serves as a means of transport for adult individuals of Indo-Pacific fishes that otherwise would not be able to cross the East Pacific Barrier. It has been heretofore believed that such long distance colonization was accomplished by movements of the ichthyoplankton. The discovery of adult forms less than 12 months after the onset of the El Niño raises serious doubts that the drift of ichthyoplankton is the sole means of dispersal.

Secondarily, major El Niño events tend to reduce the size of populations of those Galápagos fishes that are adapted to cool temperate conditions.

GEOLOGICAL SETTING AND CENOZOIC MOLLUSCAN PALEONTOLOGY OF THE GALAPAGOS ISLANDS

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The volcanic nature of the Galápagos Islands would not make them a likely candidate for preservation of fossils. Nevertheless, scattered sedimentary deposits in the islands contain molluscan remains and provide a record of the ancient shallow water marine fauna of the archipelago. The Galápagos are the subaerial peaks of volcanoes (McBirney & Williams, 1969) that sit atop the Carnegie Ridge on the Nazca Plate (Cox, 1983; Simkin, 1984). Published radiometric dates from volcanic rocks in the islands range from 0.09 ± 0.04 million years to 4.21 ± 1.81 million years (Cox, 1983; Bailey, 1976). Geologic evidence places the first subaerial emergence, and therefore the earliest possible onset of terrestrial adaptive radiation and speciation, at 3.3 million years (Hall, 1983). However, marine invertebrate colonization likely occurred prior to subaerial exposure, although Hickman & Lipps (1985) concluded that all fossiliferous marine deposits are less than about two million years old. Using magnetic stratigraphy and radiometric age determination, Geist, McBirney & Duncan (1986) recently concluded that San Cristobal Island became emergent approximately 2.3 million years ago.

Petrographic analysis has shown that sedimentary deposits in the predominantly volcanic archipelago can be divided into two lithofacies. An arkosic algal biosparite facies was observed in multiple thin-section samples from Cerro Colorado on Santa Cruz Island, South Plaza Island, Baltra Island, and from Cerro Brujo on San Cristobal Island. This facies represents beach-rock formation in the upper intertidal and supratidal zones. An ostracodal-foraminiferal biomicrite facies was observed in a single sample from an islet in Barrington Bay, Santa Fe Island. This second facies represents shallow subtidal lagoonal deposition. Many of the macromollusk fossils known from the Galápagos occur as bioclasts in these sedimentary rocks.

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NOTES ON THE MARINE MOLLUSCAN FOSSIL DEPOSITS OF THE GALAPAGOS ISLANDS

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The fossil deposit on Isla Santa Cruz that was collected during the California Academy of Sciences 1905-06 expedition to the Galápagos Islands has been thought to have been adjacent to Cerro Colorado. However Ochsner's faunal list and locality description do not match the deposits near Cerro Colorado. We were members of a 1986 expedition which relocated Ochsner's deposit about 6 km north of Cerro Colorado.

On Isla Santa Fe we located several limestone pockets containing fossils, including *Strombus propegricilior* Dall & Ochsner, 1928, which was only known from Isla Santa Cruz. The limestone pockets were isolated and previously not known from Santa Fe. One locality on Isla Santa Fe contained only a land snail of the genus *Bulimulus*, which is the first record of a fossil land snail in the Galápagos Islands.

On Isla San Cristobal fossil fragments were found on Cerro Brujo that we believe to be Darwin's locality, which had not been documented accurately.

TAPHONOMY OF TWO PLEISTOCENE TERRACE DEPOSITS ON THE GALAPAGOS ISLANDS

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Biological taphonomy is the study of how organisms affect the preservational record of, in this case, gastropod shells. Two Pleistocene terrace deposits from Villamil (Isla Isabela) and Isla Santa Fe reveal different taphonomic histories. The Villamil assemblage is dominated by predatory gastropods (*Conus*, terebrids) which are indicative of an offshore, sandy bottom community (55 meters depth). Villamil micromollusks were more diverse than the macromollusk component and many were drilled by predatory microgastropods. Villamil fossils were relatively pristine (few organismic borings; little evidence of hermit crab occupation of the shells; little subaerial erosion). In contrast, Santa Fe fossils represent a low, rocky intertidal assemblage dominated by *Thais planospira* (Lamarck, 1822) and *Muricanthus princeps* (Broderip, 1833), both predatory gastropods. Santa Fe shells were heavily bored by gastrochaenids, clionid sponges and spionid polychaetes. Hermit crabs also used some of the gastropod shells as those shells had encrusting and boring organisms associated with the shell aperture. In addition, subaerial exposure was evident as lichens, blue-green algae, chalky texture and "Iguana polish" were characteristic on many of the larger shells. The Santa Fe locality is located within an Iguana nesting site and some of the larger shells *(Muricanthus)* are smooth, grey and worn rather than white and chalky (as shells are at a non-Iguana nesting site on Isla Santa Fe), suggesting polish by them. In summary, it is unusual to have such good preservation of both a subtidal and rocky, low intertidal assemblage in the Pleistocene fossil record. The taphonomy of the rock assemblage (Santa Fe) indicates these shells were maintained in the substrate longer (by hermit crabs and/or shell accumulations), whereas most of the Villamil fossils had little exposure before burial as evidenced by the boring and encrusting organisms on the shells.

EL NINO AND GALAPAGOS CORAL REEF DEVELOPMENT: A STUDY FROM THE URVINA BAY UPLIFT, ISABELA ISLAND, GALAPAGOS

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In the Galápagos Islands, an unusual paleontologic site, Urvina Bay, is one of the best locations to examine the consequences of past El Niño warmings on eastern Pacific reef building. In 1954, along the west-central coast of Isabela Island, the upward movement of magma caused a portion of Urvina Bay to be suddenly thrust more than 7 m above sea-level, driving the shoreline 1.2 km seaward and exposing several km̀ of a marine shelf (Colgan and Malmquist, 1987). The receding waters left invertebrate and vertebrate remains, and preserved a 1954 coral community that bears the scars of previous El Niño events.

Urvina Bay's foundation is a young (around 1,000 yrs. old) "aa" lava flow, and its irregular topography and varied water depth provided many microhabitats where corals, calcareous algae, echinoderms, and mollusks settled and grew. Eight hermatypic coral species lived in the shallow waters of Urvina Bay with three species (*Pavona clavus, Pocillopora damicornis,* and *Porites lobata*) producing five, small isolated, nearly monospecific reefs. However, some individual colonies obtained an enormous size (*i.e., P. clavus,* 12 m diameter).

Urvina Bay's reefs owe their small size to several factors: seasonally cool and nutrient-rich upwelling water, low sexual reproductive success, and intense bioerosion (Glynn and Wellington, 1983). Yet the corals survive, until an El Niño warming event stresses them beyond their physiologic limits. Three El Niño warmings occurred between 1939 and 1943, with the most intense events appearing in 1941 (Glynn, 1988), and their imprint is seen in the coral colonies of the uplift. Many of the corals, both branching and massive colonies, were killed during this warming. On massive corals (*i.e. Porites lobata* and *Pavona clavus*) the upper surfaces of the colony were killed and portions of the shaded areas remained alive. The dead surfaces were infested with infaunal bioeroding clams and colonized by epifaunal molluscs (*e.g.*, vermetids). At Urvina Bay, *Pocillopora* colonies had produced the most extensive area of coral reef development, but none survived the El Niño events of the early 1940's (broken and algal encrusted upper branches testify to the coral's death prior to the uplift).

After a coral dies, crustose and fleshy algae cover its surface and it becomes an increasingly likely target for urchin grazing (Glynn *et al.*, 1979). Urchins rasp the coralla to remove algae, eroding the coral's skeleton. This action alone is not enough to quickly reduce the reef to rubble, but urchins act somewhat like beavers, undercutting the framework and toppling the coral colonies. Currents tumble these loose pieces, turning them into unconsolidated rubble. Because of these high rates of bioerosion following coral death, reef build-ups can not accumulate. This keeps coral reefs small because growth only occurs during the short time span between major El Niño events.

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RECENT MOLLUSCAN FAUNA IN THE GALAPAGOS: TAXONOMIC COMPOSITION OF THE FAUNA

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The Galápagos Islands, located in the Pacific Ocean about 600 nautical miles west of Ecuador, South America, cover a geographic area ranging from longitude 89° 15′ W to 92° 01′ W and from latitude 1° 40′ N to 1° 36′ S.

This archipelago is one of the most isolated island groups in the world. It is a part of the Panamic marine zoogeographical province, but a significant component of its shallow-water molluscan fauna seems to be endemic.

A compilation of the data given in Keen (1971) indicates a high (42%) percentage of species endemic to the islands. However this figure is probably closer to 26% (Finet, 1985) on the basis of more precise and extensive data from the collections and literature. Some new records (Finet, 1985; Finet, in preparation) permit us to modify these numbers slightly. (Table I)

TABLE I

Systematic composition of the Galápagos Islands malacofauna (only verified species for the Galápagos have been taken into consideraton).

	Number of endemic species	Number of non-endemic species	Percentage endemic
Gastropoda (486)			
Prosobranchia (447)	120	327	26.8%
Opisthobranchia and Pulmonata (39)	13	26	33.3%
Bivalvia (100)	10	90	10.0%
Polyplacophora (13)	9	4	69.2%
Scaphopoda (5)	-	5	0.0%
Cephalopoda (4)	2	2	50.0%
Total (608)	154	454	25.3%

The biogeographic distribution of the marine mollusks found in the Galápagos has been detailed previously (Finet, 1985) and is scarcely modified by the new records. Although the fauna is mostly Panamic (or endemic), its biogeographic source elements are also Californian, Peruvian, or Indo-Pacific. A small component of the malacological fauna is closely related to the Caribbean province. There are also a few species from other faunal provinces (Aleutian, Patagonian, Australian and Japonic) or that are circumtropical or tropical wide-ranging. The numbers of these species are:

endemic	154 species (on 608)	=	25.3%
pure Panamic	312 species	=	51.32%
Panamic + Californian	46 species	=	7.57%
pure Californian	0		-
Panamic + Peruvian (+ Abyssal Magellanic)	39 species	=	6.42%
Panamic + Californian + Peruvian	16 species	=	2.63%
pure Peruvian	3 species	=	0.49%
Panamic + Caribbean (+Patagonian)	4 species	=	0.66%
Panamic + Indo-Pacific	6 species	=	0.99%
pure Indo-Pacific	8 species	=	1.32%
Western Pacific wide-ranging (incl. Japonic and/or S. Australian)	4 species	=	0.66%
Circumtropical or tropical wide-ranging	12 species	=	1.98%
Worldwide	2 species	=	0.33%
Pelagic (verified occurrences)	2 species	=	0.33%

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UPDATE ON MOLLUSCS WITH INDO-PACIFIC FAUNAL AFFINITIES IN THE TROPICAL EASTERN PACIFIC—VIII

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This year, I have three species to report. Two that I took in the Galápagos, and one from Cocos Island, Costa Rica.

The first is *Tricolia (Hiloa) variabilis* (Pease, 1861). Robert Robertson described *Tricolia variabilis* as the most widespread and abundant *Tricolia* in the Indo-West Pacific. As the name implies, it has a wide range of color patterns, size, and sulpture. Its range is from East Africa to Hawaii and French Polynesia. I collected a single specimen from Manuelita, Cocos Island, Costa Rica.

The second species is *Linatella (Gelagna) succincta* (Linnaeus, 1771). Alan Beu states that the range for this species is from Gabon in West Africa, East Africa, and as far east as Hawaii. While diving in 10-17 meters off Enderby Island, Floreana Island, Galápagos, I took a single specimen.

The third species is *Cantharus (Pollia) fumosus* (Dillwyn, 1817). This species is known throughout the Indo-Pacific. I collected two specimens in the Galápagos (one from 10-17 meters depth off Champion Island, Floreana Island, Galápagos).

I also collected 2 specimens of what may be *Peristernia,* a genus previously not known from the Eastern Pacific.

AN UPDATE ON THE MOLLUSCS FROM THE GALAPAGOS ISLANDS AS LISTED IN THE PRELIMINARY FAUNAL LIST OF THE MARINE MOLLUSKS OF THE GALAPAGOS ISLANDS BY YVES FINET

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I am indebted to Yves Finet, Geneva Natural History Museum, for his 1985 paper titled "Preliminary Faunal List of the Marine Mollusks of the Galápagos Islands," in which he lists 593 verified species of molluscs and 190 species of "doubtful occurrence."

From February 13-20 of this year, Michel Montoya, Kirstie Kaiser, and I were granted permission to collect in the Galápagos. We were assisted by Gene Everson and Wayne Harland.

This report includes two species that Finet has added since 1985 (Finet 1987a and 1987b), adds two species that were in Finet's doubtful occurrence list, one species in the Los Angeles County Museum of Natural History, and species collected by Wayne Harland, Kirstie Kaiser, and me that were not included in Finet's list. All specimens are in my collection, unless otherwise noted.

Finet lists 154 species as endemic to the Galápagos, which is equal to 26 percent of his total listing. In this paper, I list six of these species, from my collection, that have been taken from outside of the Galápagos; and I add 47 species to Finet's list, which drops the endemic percentage to 23.2 percent. The percentage will undoubtedly drop as more taxa from the other collections are reported. Certainly, additional species will also be added at a later date, after Montoya, Kaiser, and Everson complete their indentifications. I also have a number of species that still await classification.

Our success in finding so many previously unreported species is primarily due to two factors. The first is that we found a number of these while diving at night. The second is that during all of my daytime dives, I was shaking rocks or dead coral into my collecting bag, which produced all of the microscocpic species that are listed.

In the following list, the taxa are generally placed in the order in which they are found in Keen (1971) and include the Keen numbers, where applicable. Those species that do not have a Keen number and that are preceded by I-P, are Indo-Pacific faunal taxa.

ADDITIONAL RECORDS

(All Panamic faunal constituants unless otherwise noted)

I-P = Indo-Pacific fauna

Gastropoda:

5 *Sinezona rimuloides* (Carpenter, 1865). Intertidally, W. of Pta. Comorandt, Floreana I.; 10-17 m., Champion I., Floreana I.

86 *Calliostoma mcleani* Shasky & Campbell, 1964. 17 m., S. side Gardner I., Española I.; 10 m., S. side Gardner I., Española I.; 13-20 m., Cousins Rock, Santiago I.

217 *Amphithalamus inclusus* Carpenter, 1865. See revisions. Intertidally W. of Pta. Comorandt, Floreana I.

236 *Rissoella johnstoni* Baker, Hanna, & Strong, 1930. Intertidally W. of PTA Comorandt, Floreana I.

238 *Rissoella tumens* (Carpenter, 1857). 10-17 m. Champion I., Floreana I.

275 *Rissoina ericana.* Hertlein & Strong, 1951. 10 m. N. tip of Baltra I.

467 *Caecum semilaeve* Carpenter, 1857. 17 m. S. side of Gardner I., Española I.

482 *Fartulum dextroversum* (Carpenter, 1857). 10 m. N. tip, Baltra I.

529 *Cerithiopsis guanacastensis* (Hertlein & Strong, 1951. 17 m. S. side Gardner I., Española I.; 10-17 m. Champion I., Floreana I.

I-P *Triphora triticea* (Pease, 1861). 17 m. S. side Gardner I., Española I.; 10-17 m. Champion I., Floreana I.

587 *Triphora oweni* Baker, 1926. 10-17 m. Champion I., Floreana I.; 7-14 m. Corona Del Diablo I., Floreana I.

694 *Eulima elegantissima* DeFolin, 1867. 10-17 m. Champion I., Floreana I.; 17 m. S. side Gardner I., Española I.

771 *Fossarus angulatus* Carpenter, 1857. Intertidally W. of Pta. Comorandt, Floreana I.

778 *Fossarus megasoma* (C.B. Adams, 1852). 7-14 m. Corona Del Diablo I., Floreana I.

I-P *Tonna perdix* (Linnaeus, 1758). See Finet 1987 B

I-P *Linatella (Gelagna) succincta* (Linnaeus, 1771) 10-17 m. Enderby I., Floreana I.

997 *Murexiella vittata* (Broderip, 1833).

— *Aspella pollux* Radwin & d'Attilio, 1976. 13 m. Champion I., Floreana I.

1095 *Neorapana muricata* (Broderip, 1832). Harland Collection

I-P *Cantharus fumosus (Dillwyn, 1817).* 10-17 m. Champion I., Floreana I.

1295 *Nassarius corpulentus* (C.B. Adams, 1852). 7-10 m. S. side N. Plaza I., Santa Cruz I.

Nassarius caelolineatus Nesbitt & Pitt, 1986. 7-10 m. S. side N. Plaza I., Santa Cruz I. 17-22 m. N. side N. Plaza I., Santa Cruz I.

1462 *Cancellaria pulchra* Sowerby, 1832. Kaiser Collection (Removed from doubtful list) 13 m. Gardner I., Española Island.

1512 *Conus (Lithoconus) tessulatus* Born, 1778. 10 m. N. tip of Baltra I. (small, dead specimen)

1776 *Clathurella rigida* (Hinds, 1843). 10-17 m. Champion I., Floreana I.

1884 *Pyramidella (Pharcidella) hastata* (A. Adams in Sowerby 1854). 15 m. in sand, Pta. Comorandt, Floreana I.

1995 *Odostomia (Menestho) grijalvae* Baker, Hanna, & Strong, 1928. 10 m. N. tip, Baltra I.

2050 *Turbonilla (Chemnitzia) sinaloana* Strong, 1949. Intertidally, Pta. Comorandt, Floreana I.; 17-20 m. Cousins Rock, Santiago I.; 10 m. Champion I., Floreana I.

2053 *Turbonilla (Cingulina) evermanni* Baker, Hanna, & Strong, 1928. 7-14 m. Corona Del Diablo I., Floreana I; 10-17 m. Enderby I., Floreana I.

781 *Phasianema saxicola* (C.B. Adams, 1852) [*Litiopa*] [*Fossarus* in Keen] 17-20 m. Cousins Rock, Santiago I.

I-P *Herviera glirella* (Melvill & Standen, 1896). 10 m. Champion I., Floreana I.

2283 *Diacria quadridentata* (Blanville, 1821, ex Lesueur, MS). 17 m. S. side Gardner I., Española I.

2315 *Julia thecaphora* (Carpenter, 1857). Intertidally, Bartolome I.

Bivalvia:

129 *Septifer zeteki* Hertlein & Strong, 1946. (Removed from doubtful list)

156 *Pinna rugosa* Sowerby, 1835. (See Finet 1987 a)

381 *Verticordia isocardia* (Verrill, 1870). Kaiser Collection. 18 m. Gardner I., Española I.; 17 m. Enderby I., Floreana I.; 20 m. Pta. Suarez, Española I.; 27 m. Albany Rock, Santiago I.

TAXA REMOVED FROM ENDEMIC LIST (From Specimens in the Shasky Collection)

113 *Gaza rathbuni.* Dall, 1890. Gulf of Panama

128 *Arene guttata.* McLean, 1970. Cocos Islands

159 *Tricolia diantha.* McLean, 1970. Cocos Island

1042 *Trophon sentus.* (Berry, 1969). Salango Island, Ecuador

1446 *Thala jeancateae.* Sphon, 1969. Cocos Island, and Bahia Ballena, Gulf of Nicoya, Costa Rica

646 *Semele rupium* (Sowerby, 1833) Cocos Island.

REVISIONS OF NOMENCLATURE

Barleeidae

196 *Lirobarleeia galapagensis* (Bartsch, 1911)

199 *Lirobarleeia halia* (Bartsch, 1911)

201 *Lirobarleeia hoodensis* (Bartsch, 1911)

208 *Lirobarleeia nemo* (Barsch, 1911)

217 *Amphithalamus inclusus* Carpenter, 1865

For all of above see Ponder, 1983.

Rissoinidae

276 *Rissoina insignis* (DeFolin, 1867). According to Ponder, 1985, *R. signae* (Bartsch, 1915) is a junior synonym.

Vanikoridae

797 *Vanikoro aperta* (Carpenter, 1864). I am unable to find any character differences between *V. aperta* and *V. galapagana* (Hertlein & Strong, 1951)

Muricidae

1022 *Evokesia rufonotata* (Carpenter, 1864). This species has been listed in various genera. See Radwin & D' Attilio, 1975.

Nassariidae

— *Nassarius caelolineatus,* Nesbitt & Pitt, 1986. Previous records of *N. nodicinctus* in the Galápagos have been shown to be in error. See Nesbitt & Pitt, 1986.

I thank Dr. Finet for reviewing this paper and making corrections.

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LIVING BIVALVIA OF THE GALAPAGOS ISLANDS

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Though much attention has been devoted to the factors influencing the marine biogeography of the Galápagos Islands (Abbott 1966), and systematic sampling of the fauna occurred prior to 1829 (Howell 1941), the living bivalves have been poorly surveyed, leading to erroneous conceptions of depauperation and endemicity. The first inventory (Carpenter 1857) listed 16 bivalves, while the last comprehensive catalogue based on systematic research cited 38 species (Hertlein & Strong 1955), and recent reports of expeditions include few bivalves (Taviani 1979). The standard work on the region (Keen 1971, updated by Keen & Coan 1975) includes 44 species of bivalves known from the Galápagos Islands.

A rapid survey of the extensive Galápagos material in the Alan Hancock Foundation of the University of Southern California yielded 90 bivalve species (Bernard 1983), in line with a recent list based on the literature and named material in museum collections (Finet 1985). In 1984 the Alan Hancock material was acccessioned into the holdings of the Los Angeles County Museum of Natural History and I reviewed the material. Some records, based on labeling errors were removed. The balance of specimens, amalgamating the Alan Hancock material with smaller collections taken by the Anton Brunn Expeditions, and expeditions under the aegis of LACM (Searcher 308, Ameripagos 1), resulted in 284 stations in the Galápagos yielding 686 lots of bivalves, resulting in a total of 187 species of bivalves (including 17 species in other institutions). 52 lots of mud samples, containing numerous minute bivalves still require attention and will increase the number of bivalves known from the Galápagos Islands.

The bivalve fauna of the Galápagos Islands can no longer be considered depauperate, though it is only one third of the diversity occurring on the adjacent mainland America coastline. Less than 3% of the bivalves are endemic, 2% reveal an Indo-Pacific affinity and 95% are Panamic and warm water Peruvian, but Chilean species are not represented. Some 28% of the bivalves are Caribbean cognate species, a slightly higher percentage than that of the mainland coast. Because of the poor distribution of the collecting sites, no inter-island zoogeographic conclusions can be drawn, and bivalves present principally reflect substrate type. There is no evidence of a deep water endemic element, the majority of abyssal species being widely distributed throughout the Pacific Basin.

Further research will doubtless increase the number of species known from the Galápagos and other offshore islands. For example, 16 bivalves were known from Cocos Island (Montoya 1983). More collecting effort and systematic research has increased this to 72 species (Montoya *et al.*, 1988). A list of the Galápagos bivalve species and location of deposition is in preparation (Bernard & McKinnell).

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SOME BIVALVE RECORDS FROM THE GALAPAGOS ISLANDS

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A close look at several marine bivalves has had an impact on our knowledge of the Galápagos fauna and raises more general questions about eastern Pacific island faunas.

Halodakra subtrigona (Carpenter, 1857) occurs on Isla San Salvador in the Galápagos. It broods its young, which raises the question about how and when it got to the Galápagos. Any comprehensive review of the Galápagos and other island faunas needs to give special consideration to brooders. Moreover, this species has a very wide distribution, from Tomales Bay, California, to Peru. Is such a wide distribution to be considered unusual in a brooder?

Records of *Semele solida* (Gray, 1828) from Isla Isabela and of *S. corrugata* (Sowerby, 1833) from Isla Baltra are based on beachworm valves of *S. flavescens* (Gould, 1851), which has not previously been reported from the Galápagos. So, two names can be removed from the list of Galápagos taxa, but is there one to add? *Semele flavescens* is the most common *Semele* in eastern Pacific collections, and it lives in shallow water. Perhaps these valves represent stray larval settlement, and it is not established. How many other island records might be based on occasional recruitment that does not result in species establishment? Perhaps we should institute a way to rank how sure we are about whether populations of each species actually live there.

From the point of view of understanding the process of speciation, island taxa with tenuous connections to mainland populations may be particularly worthy of careful study, in contrast to the many taxa with more constant gene flow with mainland populations. How can we find out what is the case for different taxa?

The Californian species *Semele decisa* (Conrad, 1837) was reported from the Galápagos, but what people were actually finding is the similar *S. sowerbyi* Tryon, 1869. There are no species as closely related in the intervening Panamic province, living or fossil. There is nothing similar in the Indo-Pacific.

Semele rupium (Sowerby, 1833) nestles in coral rubble in the Galápagos Islands and on Cocos Island. It belongs in the subgenus *Elegantula*, the type species of which is *Semele striata*, a nestler in sponges, occurring from the Red Sea and off east Africa. I know of no similar taxa in the rest of the Indo-Pacific or elsewhere, except for *Semele rupicola* Dall, 1915, which lives from central California to the outer coast of southern Baja California. It nestles in rock crevices, and it is very similar to *Semele rupium*.

Does this last species pair represent independent recruitment events from the Indo-Pacific long ago? Do these two species-pairs represent the remnants of once-wider occurrences in the eastern Pacific? Or do they represent point-to-point settlement events within the eastern Pacific?

Surface water temperature maps during the 1982-1983 El Niño event seemed to show masses of warm surface water moving northward across the prevailing eastward and westward equatorial currents. Could such events account for the distributions of such species-pairs as these of *Semele?*

Semele rupium has been found on ten of the Galápagos Islands, as well as on Cocos Island, whereas *S. sowerbyi* has been found on only four of the islands. Why do they differ? There is much to learn as the marine faunas of each island are better known.

I recently reported *Semele purpurascens* (Gmelin, 1791) from the Galápagos. It occurs elsewhere in the eastern Pacific, as well as in the Caribbean. In publications on eastern Pacific islands, statements are generally made about the affinities of their faunas with those of other provinces, including that of the closely related Caribbean. In some works the statistics on faunal affinity are based only on such identical taxa as this *Semele*. Others take into account homologous species pairs, where these are known. But, there aren't any universal standards for which taxa are considered identical, which identical but differing somewhat in morphology, which separate but differing in minor ways, or which separate and differing in more significant ways. For these reasons, statistics on faunal affinity aren't easily comparable from paper to paper. Some standardization of approach is desirable.

I recently reported *Semele venusta* (Reeve, 1853) from the Galápagos, synonymizing the Californian *S. incongrua* Carpenter, 1864, with it. Specimens from California, the northern Gulf of California, and the Galápagos have thinner shells, with sharper, more frilly sculpture than material from the rest of the Panamic province. What can we say in general about patterns of morphological differences between island occurrences of other Panamic species and their mainland populations?

The recently described *Semele jamesi* Coan, 1988, which occurs from the Gulf of California to Ecuador, is not yet known to occur on the Galápagos. It is evidently common throughout the Panamic province, and its type locality is Cocos Island, indicating that it is able to reach offshore islands. If it really isn't present, why has such a wide-spread species not reached the Galápagos? Can we draw any conclusions from the pattern of species that aren't present on the Galápagos?

Cyathodonta galapagana is known only from a single valve dredged from 73 meters in the southern Galápagos. It is really a *Bushia*. There are also described species of this genus from Florida and from the Bay of Panama, and I have a new species from the Gulf of California. Three of these taxa are extremely rare and are known from only one or two specimens. Such rarity is characteristic of species of the Thraciidae. The fact that *Bushia galapagana* has thus far been found only in the Galápagos may say more about the Thraciidae than about the fauna of the Galápagos.

To fully understand what a species list actually says about island faunas, we really need to know the characteristics of the distributional patterns of the groups involved.

Those working on the faunas of the Galápagos and Cocos Island might try a statistical experiment: take some arbitrary point in the Panamic province of similar geographic size and environmental diversity to the Galápagos Islands and from which there is a good checklist. Update the taxonomic information. Pretend that it is an island. Perform the kinds of statistical measures and reach the kinds of biogeographic conclusions that are done for islands. Compare the results with those from the Galápagos. This exercise might tell us someting interesting about the validity of our conclusions about the affinity of the Galápagos and other island faunas.

The Galápagos marine molluscan fauna and those of the other eastern Pacific offshore islands have a lot of biogeographic information to reveal, but we are past the point at which simple lists of taxa will tell us very much of interest.

The newly emerging nucleic acid techniques could tell us much about the divergences of various island taxa. A good standard for comparing island isolates might be the mainland species pairs separated by the isthmus of Panama for a known time, 3.1 million years. Short of this approach simply taking a much closer look at the particular groups involved in connection with taxonomic revisions will shed much new light.

DISTRIBUTIONS OF LAND SHELLS AND PLANTS ON SANTA CRUZ AND SANTA MARIA ISLANDS, GALAPAGOS

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The junior author (SI), a member of the 1964 Galápagos International Scientific Project, made a south-north transect from Bahía Academy via Bella Vista up to the pass between Mt. Crocker and Cerro Puntudo and farther down to an altitude of 350 m on the northern slope on Santa Cruz Island, and a west-east transect along Black Beach to Saddle Hill on Santa Maria Island in order to study plant ecology of the Galápagos. Land snails associated with plants and collected alive at that time were dried and deposited at the University of Colorado Museum. This small collection of landshells was identified and studied by the senior author (S-KW).

Plant zonation on Santa Cruz Island has already been documented (Itow, 1965, 1971; Itow & Weber, 1974). The southern slope can be divided into 6 zones: (1) Dry Zone (0-40 m, *Bursera* forests mixed with or without *Opuntia*); (2) Transition Zone (40-180 m, *Pisonia*/*Psidium* forests mixed with *Bursera* and prominent with epiphytic lichens); (3) *Scalesia* Forest Zone (180-280 m); (4) Brown Zone (280-420 m); (5) *Miconia* Belt (420-580 m); and (6) Grassland Zone (580-860 m). The northern slope can be divided into 4 zones: (1) Dry Zone (0-430 m); (2) Transition Zone (430-560 m); (3) *Scalesia* Forest Zone (560-670 m); and (4) Grassland Zone (670-860 m). Land snails were associated with 4 genera of plants (*Pisonia, Scalesia, Bursera* and *Psidium*) between 140 and 560 m. The plant zonation found on Santa Cruz Island can also be found elsewhere (Dall & Ochsner, 1928; Smith, 1966; Wiggins & Porter, 1971; Coppois, 1984).

The vegetation zones on Santa Maria Island were largely destroyed since the 1830's settlement. In 1964, *Bursera graveolens* was most conspicuous at low altitudes (0 to 280 m). *Scalesia pedunculata* was found at altitudes of 280, 300, 320, 350 and 400 m. *Macraea laricifolia*, an infrequent bush, was occasionally found at 45, 230, 240, 280, 320, 460, 470, 530 and 560 m along the Black Beach Road. The areas at middle and higher altitudes were widely covered by the introduced species, *Psidium guajava*. The last 3 species were found to have associated land snails.

The small collection of land shells from the Galápagos housed at the University of Colorado Museum contains one operculate land species, *Helicina nesiotica* Dall, and 9 pulmonate species: *Pupisoma galapagorum* Pilsbry, *Tornatellides chathamensis* (Dall), *T. kahoolavensis* Cooke & Pease, *Opeas micra* (Orbigny), *Bulimulus nux* Broderip, *Succinea brevior* Smith, *S. bettii* Smith, *S. producta* Reibisch and *Euconulus galapaganus* Dall. *Succinea brevior* and *E. galapaganus* were common species on both islands. *Succinea bettii* was found on Santa Cruz Island and *S. producta* was found on Santa Maria only.

The collecting sites and altitudinal distributions of plants and land snails are shown on Figs. 1-2. *Euconulus galapaganus, Succinea bettii* and *S. producta* were likely dwellers of the middle and lower zones whereas the remaining species occurred at the middle and higher zones. The relationship between land snails and plants changed as the altitudes increased (Figs. 1-2). Land snail distributions were most likely correlated with lichens and mosses covering the bark of tree trunks than the shrubby plant species.

Tornatellides kahoolavensis is a new record for the Galápagos land snail fauna. *Tornatellides* is the only genus found in the Galápagos that has Polynesian affinities, whereas the remaining known snails are distinctly American (Pilsbry & Cooke, 1915-1916).

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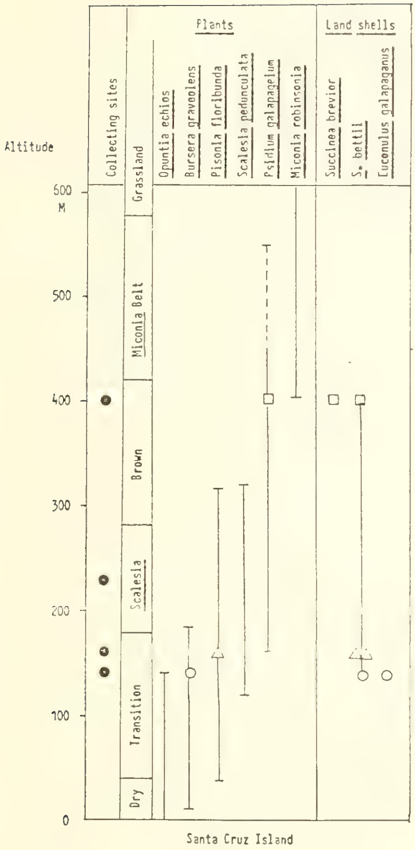

FIGURE 1

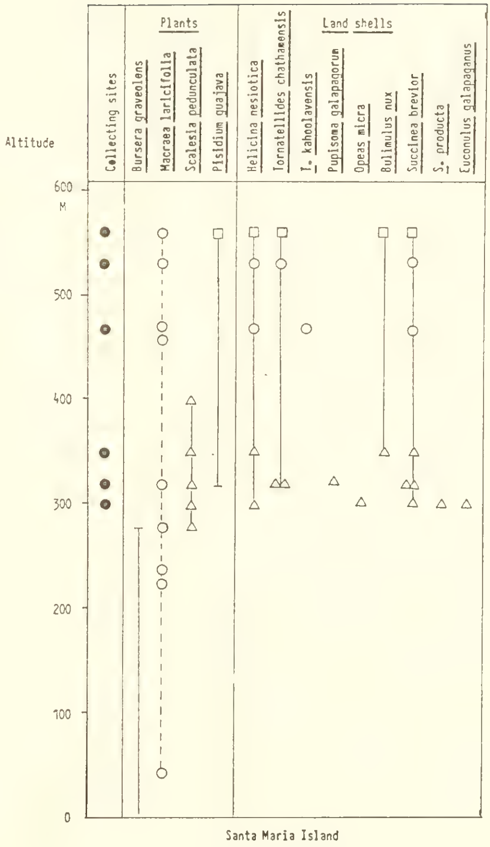

FIGURE 2

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CHARLES DARWIN'S CONTRIBUTION TO THE MOLLUSCAN FAUNA OF THE GALAPAGOS ISLANDS: HISTORICAL PERSPECTIVE ON ENDEMICITY AND BIOGEOGRAPHY

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Charles Darwin visited the Galápagos Islands from September 15 to October 20, 1835, during the *Beagle* voyage (Keynes, 1979; Burkhardt and Smith, 1985.) Particularly noteworthy of his natural history observations during these five weeks were those concerning the terrestrial biota of the archipelago. His comments about the marine invertebrate fauna of the islands have received much less attention in the literature. Following his return to England on October 2, 1836, Darwin received taxonomic information about various components of the marine fauna of the islands, including the molluscan fauna (Dance, 1986), from a variety of contemporary taxonomic specialists. Among those supplying information to Darwin about the Galápagos biota was the famous collector Hugh Cuming, who visited the islands in 1829 (Dance, 1980), about five years prior to the *Beagle* voyage.

Darwin included only ten sentences in his *Journal of Researches* (1839) concerning the Galápagos molluscan fauna. However, this short passage in one of Darwin's earliest publications following the return of the *Beagle*, contains considerable information about Darwin's perception of the biogeographic affinities of the fauna. By examining the statements made by Darwin concerning the overall uniqueness and degree of endemicity of the malacofauna, it is possible to better understand, in part, his predilection to attribute unique evolutionary status to the Galápagos fauna, as revealed 20 years later in the *Origin of Species* (1859). The complete passage is reprinted here in order to examine Darwin's statements as they originally appeared (generic names italicized here for clarity):

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evolutionary status to the Galápagos fauna, as revealed 20 years later in the *Origin of Species* (1859). The complete passage is reprinted here in order to examine Darwin's statements as they originally appeared

> "Of land-shells I collected sixteen kinds (and two marked varieties), of which, with the exception of one *Helix* found at Tahiti, all are peculiar to this archipelago: a single fresh-water shell *(Paludina)* is common to Tahiti and Van Diemen's Land. Mr. Cuming, before our voyage, procured here ninety species of sea-shells, and this does not include several species not yet specifically examined, of *Trochus, Turbo, Monodonta,* and *Nassa.* He has been kind enough to give me the following interesting results: of ninety shells, no less than forty-seven are unknown elsewhere — a wonderful fact, considering how widely distributed sea-shells generally are. Of the forty-three shells found in other parts of the world, twenty-five inhabit the western coast of America, and of these eight are distinguishable as varieties; the remaining eighteen (including one new variety) were found by Mr. Cuming in the Low archipelago, and some of them also at the Philippines. This fact of shells from islands in the central part of the Pacific occurring here, deserves notice, for not one single sea-shell is known to be common to the islands of that ocean and to the west coast of America. The space of open sea running north and south off the west coast, separates two quite distinct conchological provinces; but at the Galápagos we have a halting place, where many new forms have been created, and whither these two great conchological provinces have each sent several colonists. The American province has also sent here representative species; for there is a Galapageian species of *Monoceras,* a genus only found on the west coast of America; and there are Galapageian species of *Fissurella* and *Cancellaria,* genera common on the west coast, but not found (as I am informed by Mr. Cuming) in the central islands of the Pacific. On the other hand, there are Galapageian species of *Oniscia* and *Stylifer,* genera common to the West Indies and to the Chinese and Indian seas, but not found either on the west coast of America or in the central Pacific. I may here add, that after the comparison of Messrs. Cuming and Hinds of about 2000 shells from the eastern and western coasts of America, only one shell was found in common, namely, the *Purpura patula,* which inhabits the West Indies, the coast of Panama, and the Galápagos. We have, therefore, in this quarter of the world, three great conchological sea-provinces, quite distinct, though surprisingly near each other, being separated by long north and south spaces either of land or of open sea."

Problems with accurately calculating the degree of endemicity notwithstanding, Darwin was left with the impression that 52% (47 out of 90 species) of the prosobranch fauna of the islands was endemic. This inflated estimate of endemicity is clearly the result of a small sample size, limited collecting area, and perhaps biased taxonomic treatment by Cuming. Darwin extends his observations from the mere taxonomic list provided by Cuming to broader concepts about biogeographic affinities (see Ghiselin, 1984: 32-45) and mechanisms of long distance dispersal. Darwin comments on the biogeographic affinities of the Galapagos malacofauna by noting the known distribution of the non-endemic components of the fauna. He divided the remaining fauna into four of the principal biogeographic provinces recognized for Galápagos mollusks by James (1984) and other authors: 1) Panamic Province (= American in Darwin's terminology), 2) Indo-Pacific Province (based on similarities with the Low or Tuamotu Archipelago and the Philippine Islands), 3) Caribbean Province (West Indies in Darwin's terminology) and 4) Endemic component (based on the species identifications provided by Cuming.)

Studying Darwin's contribution is not only an historical analysis of the writings of a major figure in the development of modern biology, but also a method of further understanding the molluscan fauna of the Galapagos Islands.

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CONCLUDING REMARKS

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I thank all of the symposium contributors for presenting an interesting and intellectually stimulating series of papers.

Two themes emerge: 1) calculating endemism is fraught with error from restricted geographic collecting areas and limited knowledge of species distributions, and sometimes compounded by taxonomic discrepancies. 2) Authors who provide lists of taxa occurring in a particular area, such as the Galápagos, owe it to the scholarly community to provide comprehensive information about the sources of species occurrences (museum number, literature citation, or personal observation) in order to facilitate replication and verification of distribution records.

Of concern to all the symposium participants are the alteration and deterioration of marine and terrestrial habitats in the archipelago. These changes are the result of increased human habitation by native Ecuadorians and increased tourist travel by foreigners to the islands. These changes are not likely to end soon.

I hope this symposium serves to focus our thinking about what we know and what we do not know about the Galápagos molluscan fauna and what we need to do in the future to increase our knowledge. I hope as more is learned about the living and fossil faunas of the Galápagos that additional symposia such as this will be convened in order to exchange information and ideas about a region of the world that is fascinating not only to us scientists, but also to the general population.

MINIMIZED EFFECTS OF DENSELY CONCENTRATED GASTROPOD MOLLUSCS ON DIATOM COMMUNITIES IN SHALLOW BAY ENVIRONMENTS

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Most reported examples of marine herbivore-plant relationships are negative influences of browsing, in which algal growth is slowed by common animals such as marine molluscs and crustaceans. However, particular algae, including digestion-resistant diatoms and encrusting algae, often thrive among dense populations of molluscan herbivores that eat these algae selectively. Various lines of evidence of direct algal consumption comes from microacoustics and other detailed monitoring of foraging behavior. Yet several ingested algae often appear to persist, largely through augmented algal regeneration and recruitment among herbivores.

Dense *Bittium varium* (Pfeiffer, 1840) in Corpus Christi Bay, Texas, and *Cerithidea californica* (Haldeman, 1840) in San Francisco Bay, California, show no major depletions of their diatom foods, which are found on erect vascular plants and on sediment. Animal-enhanced diatom deposition, as recruitment, includes frequent survival in and on adhesive feces of these snails. Such simple animal-augmented algal recruitment may be widespread.

This phenomenon seems analogous to well accepted examples of terrestrial seed deposition by herbivores. For an alga, alternative reproduction would be random disperal into unsuitably deep, dark habitats. Digestion-resistant algal propagules and animal-mediated deposition appears to be a likely possibility in numerous environments where foods may have evolved such subterfuge among intense concentrations of consumers.

RADULAR TYPE, MODE OF FEEDING, AND POTENTIAL STRUCTURAL DEFENSES OF ALGAE

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The Patellogastropoda have a simple docoglossan radular type, characterized by few teeth per row. The radular teeth are mineralized with iron and silica, and the radular motion is quite simple. Mechanical tests of predicted structural defenses of algae show that thallus form and calcification are not effective structural defenses against this type of grazer. Tooth shape and the number of effective teeth per row influence the effectiveness of the radula in removing tissue from various algae. Tooth wear rates may also be important, but they may be counteracted by very high replacement rates.

The Patellogastropod radula is contrasted with the radula of the Polyplacophora. The chiton radula usually has 17 teeth per row, but most teeth are reduced in size. The two major cusps are mineralized with iron, and the radular motion is more complex, with the teeth moving laterally during the effective part of the feeding stroke. These differences have important consequences for the potential types of algae these herbivores may consume. Tooth shapes are similar to those of limpets, which feed on similar types of plants.

Finally, I would like to suggest that algal structural defenses may be directed more toward reducing the consequences of herbivore damage than preventing it. Thallus form and calcification do not appear to make tissue removal from plants more difficult. Experiments conducted with an intertidal kelp show that tissue loss from simulated chiton damage was minimized due to preferential tearing of the thallus in directions that would limit tissue loss. Data from the tropics also suggest that calcification could reduce the tearing of herbivore-damaged plants.

THE EFFECT OF HERBIVORES ON THE RATE OF SUCCESSION

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Herbivores have been shown to increase, decrease, or have no effect on the rate of succession. I present a simple, predictive model of how herbivores affect the rate of succession as a function of the successional status of the species consumed and the effect of early colonists on the establishment of later successional species. The magnitude of the herbivores' effect on succession is predicted to depend on the intensity of consumption

The model was tested in a high intertidal community. Barnacles, early colonists of disturbed areas, facilitated the establishment of several species of macroalgae, *Pelvetiopsis limitata* (Setchell) Gardner, and *Endocladia muricata* (Postels and Ruprecht) J.G. Agardh. The limpets, *Lottia digitalis* (Rathke, 1833) and *Lottia strigatella* (Carpenter, 1864), had a greater impact on algal establishment than barnacle establishment. As predicted by my model, a field experiment indicated that these herbivores decreased the rate of succession in the community.

THE EFFECTS OF LIMPET GRAZING ON ALGAL POPULATIONS: THE ROLE OF DESICCATION

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Physical factors, such as desiccation, are presumed to determine the upper limits of most intertidal organisms, but the relative importance of herbivory and other biotic factors is poorly understood. It has been shown experimentally that herbivores in many communities enchance the establishment of competitively inferior algae, if they preferentally remove superior competitors. The effect of herbivores on the upper limits of algae, however, has received little attention. In this study, I experimentally evaluate the effects of desiccation and herbivory on the vegetative growth, reproduction, and recruitment of an alga, at the upper limit of its intertidal range.

Within established beds of the perennial red alga, *Iridaea cornucopiae*, limpet grazers (*Lottia digitalis, L. pelta,* and *L. strigatella*) enhance establishment of *Iridaea* by removing competitively superior early-and mid-successional algae (*e.g., Mastocarpus papillatus* and *Endocladia muricata*.) Above the relatively discrete upper edge of *Iridaea* beds, however, a distinct band of mid-successional algae persists. Near this limit, visible desiccation damage to *Iridaea* and dense summer-time aggregations of *L. digitalis* suggest that both desiccation and limpet grazing may play a role in setting the upper limits of *Iridaea*.

To evaluate the effects of desiccation and limpets on *Iridaea* at the upper limit of its intertidal range, I experimentally manipulated both factors in a field experiment. After six months, desiccation inhibited upward vegetative growth, while limpets had no effect. After 1 year an inhibiting effect of grazers was apparent. A significant desiccation-by-grazer interaction affected both reproduction and recruitment. In moist plots, grazers enhanced both reproduction and recruitment; in dry plots, grazers reduced reproductive allocation and prevented recruitment. Microalgae may mediate these effects on recruitment. Limpets may remove competing microalgae from moist plots, permitting enhanced establishment of *Iridaea*. In dry plots, where microalgae may be less abundant, limpets may switch to *Iridaea*. Thus, the effect of grazers on *Iridaea* changes with the desiccation regime. Experiments in progress have been designed to determine whether limpet feeding preferences are affected by desiccation of *Iridaea* and whether desiccation affects the ability of *Iridaea* to recover from simulated grazing damage.

Either removal of limpets or reduction of desiccation, or both, permits *Iridaea* to invade above its usual vertical range. Thus, biotic as well as physical factors appear to set the upper limit of this alga.

DIET SPECIFICITY AND FLEXIBILITY OF THE SACOGLOSSAN OPISTHOBRANCH *PLACIDA DENDRITICA*

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The sacoglossan *Placida dendritica* (Alder & Hancock, 1843) feeds on three species of green algae along the central coast of Oregon: *Bryopsis corticulans, Codium fragile* (Suringar) Hariot, and *C. setchellii* Gardner. Laboratory feeding preference and growth experiments indicate that *Placida* individuals specialize on a single algal species with limited, but varying, capacity to switch to other algal species. While many *C. setchellii*-feeders are able to switch to *C. fragile,* few *C. fragile*-feeders are able to switch to *C. setchellii.* Some *Codium*-feeders can switch to *Bryopsis,* but very few *Bryopsis*-feeders can switch to *Codium.* Individuals that do not switch algal diets will starve in the presence of non-food algae. The feeding activities of conspecifics do not induce non-switchers to feed. This case of interindividual variation in diet specificity and flexibility has important implications for foraging theory.

SLIT-LIMPETS FROM HYDROTHERMAL VENTS

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Six new species of slit-limpets endemic to the hydrothermal vent habitat have shells and external anatomy that are similar, although evidence derived from study of internal anatomy by Gerhard Haszprunar indicates two families in two different superfamilies.

The family Scissurellidae is represented by three monotypic genera, one from the Juan de Fuca Ridge, one at the East Pacific Rise near 21° N., and one from the East Pacific Rise near 12° N. These limpets have a long open slit deflected to the right and a small operculum; the anatomy and radula agree with that of Scissurellidae. These are the only hydrothermal vent limpets with no reproductive specializations, the only group not requiring a new family.

A new family of Fissurellacea has such fissurellid characters as reduced left kidney and anal gland, but has non-fissurellid characters including a unique radula, a pedal gland, and internal fertilization with receptaculum in females. Two new genera are represented. One genus with an asymmetrical open slit has two species from hydrothermal sites in the eastern Pacific. Another genus with a single species from the Mariana vents has a closed slit.

PRELIMINARY REPORT ON THE VITRINELLIDAE FROM SAN FELIPE, BAJA CALIFORNIA, MEXICO, FROM THE GEMMELL COLLECTION (1965-1976)

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Based on the material collected by Joyce Gemmell from 1965 to 1976 in San Felipe and Puertecitos in the northwestern Gulf of California, Mexico, 25 species of Vitrinellidae have been identified, some tentatively. Seventeen of the species have not previously been reported from this area.

The material was mostly dredged, collected in grunge or found in sea star stomachs. With few exceptions the vitrinellids' diameters are under 5 mm, and it was necessary to make camera lucida drawings to aid in identification.

The only major taxonomic review of the eastern Pacific vitrinellids (Pilsbry and Olsson 1945, 1952) was followed. Generic assignments for this family however, are still problematic, and most are based on shell characters alone.

Fourteen of the species from the Gemmell collection are placed in *Cyclostremiscus* Pilsbry and Olsson, 1946. Four of these were not identified to species level. Of the ten identified, *Cyclostremiscus janus* (C.B. Adams, 1852), *C. psix* Pilsbry and Olsson, 1952, *C. nodosus* Pilsbry and Olsson, 1952 (non Carpenter, 1857), *C. perparvus* (C.B. Adams, 1852), *C. parvus* (C.B. Adams, 1852), *C. trigonatus* (Carpenter, 1857), *C. bailyi* (Hertlein and Strong, 1951) and *C. tenuisculptus* (Carpenter, 1865) are recorded for the first time in the northern Gulf of California.

Of the three species of *Teinostoma* H. and A. Adams, 1853, that were collected, only *T. imperfectum* Pilsbry and Olsson, 1952, had not previously been documented from the Gulf of California.

Of three species of *Vitrinella* C.B. Adams 1850, collected, *V. zonitoides* Pilsbry and Olsson, 1952, is recorded for the first time in the Gulf and *V. goniomphala* Pilsbry and Olsson, 1952, for the first time in the northern Gulf.

Alleorus deprellus Strong, 1938, is listed for the first time from the northern Gulf.

Four species of *Solariorbis* Conrad, 1865, were taken, one not identified to species. The other three, *S. annulatus* (Carpenter, 1857), *S. hypolius* Pilsbry and Olsson, 1952, and *S. carinatus* (Carpenter, 1857) are noted for the first time in the Gulf.

CEPHALOPODS IN MOVIES

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Octopuses and squids figure prominently in some major Hollywood movies. While they have usually been portrayed as "monsters of the deep" some cephalopods have been used sympathetically for color and even humor in movies. After reviewing about 200 movies on marine-related subjects 22 were found to show cephalopods and 32 more, unavailable for viewing, were definite possibilities. Film clips from the movies with cephalopods in them, dating from 1939 to 1984, illustrate the inaccuracies in the depiction of cinematic cephalopod biology.

MIDDLE EOCENE ROCKY NEARSHORE MOLLUSCS, TEJON FORMATION, TEHACHAPI MOUNTAINS, CALIFORNIA

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Intensive collecting in the rarely exposed basal part of the marine Tejon Formation, Tehachapi Mountains, Southern California, has revealed a new stratigraphic occurrence of the bivalves *Lithophaga*?, *Isognomon, Chama,* two fissurellacean limpets (*Hemitoma*?, *Diodora*?), and two or possibly three patellacean limpet species. Reports of these mollusks from West Coast Paleogene strata are very uncommon.

The basal part of the Tejon Formation is normally covered by extensive landslides and/or slope wash. A roadcut along the east side of the Edmonston Pumping Plant, near Grapevine, California, however, exposes a 122-m-thick section.

The lowermost 27 m consists of shoreline-associated deposits laid down as a transgressing sea advanced over an irregular surface of gneissic bedrock that locally has as much as 6 m of relief. Interbedded channel-lag, storm accumulations contain oyster hash (*Acutostrea idriaensis idriaensis*) and other mollusks indicative of a rocky nearshore environment. These mollusks, which are mostly poorly preserved, are: unidentified chitons; the bivalves *Barbatia* aff. *landesi, Brachidontes dichotomus, Lithophaga*?, *Isognomon clarki, Spondylus carlosensis, Anomia mcgoniglensis, and Chama grunskyi*; the gastropods *Diodora*?, 2 or 3 patellacean limpets, *Crepidula inornata*, and *Calyptraea diegoana*. The solitary ahermatypic coral *Dendrophyllia tejonensis* is common. At 13 m above the base of the section numerous *Isognomon clarki* valves (up to 9 cm in length) were found in closely packed layers with some articulated specimens. *Lithophaga*? was found in boreholes in a few of the thicker shelled *Isognomon*. Large patellacean limpets (up to 5.5 cm in length) were also found at the 13 m level.

Above 27 m, mollusk-bearing channels become scarcer, and mollusks (*e.g., Acanthocardia brewerii, Pitar uvasanus, Turritella uvasana uvasana, T. buwaldana*) indicative of a sublittoral environment become increasingly more prevalent. A molluscan assemblage at 63 m yielded only a few specimens of the same rocky nearshore species found downsection, and rare specimens of a possible *Hemitoma*.

The lower 63 m of the section is middle Eocene in age ("Transition Stage") based on overlapping range zones of *Turritella uvasana uvasana* and *Ficopsis remondii crescentensis*. The overlying 59 m is middle Eocene in age (lowermost "Tejon Stage") based on the rare presence of *Turritella uvasana sargeanti*.

THE INVASION OF EUROPE BY *POTAMOPYRGUS JENKINSI*— SEX RATIO AS A STRATEGY?

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The viviparous snail *Potamopyrgus jenkinsi* (Prosobranchia, Hydrobiidae) was first found in England in the River Thames in 1859 and described as *Hydrobia jenkinsi* by Smith (1889). It was introduced from New Zealand, presumably in the freshwater tanks of ships. This species continues to spread through Europe.

My work focuses on dispersal mechanisms. Migration by creeping is slow and cannot explain dispersal patterns. Instead, adult snails with thick shells survive in fish guts (Haynes *et al.*, 1985), and small snails disperse on floating algal bundles. Long-distance dispersal occurs by birds (Coates, 1922) and humans.

Eutrophication of many European waters enhances the spread of *P. jenkinsi,* because the species feeds on detritus and algae. Invasion events are described by a number of authors. Densities increase rapidly to often more than 100,000 individuals/m^2. After the initial increase, populations always decline and often disappear.

The European populations are mostly parthenogenetic females, although males are sometimes present (Wallace, 1979). The sex ratio changes over time (Wallace, 1985). Warwick (1952) defined four morphotypes, and an electrophoretic study by Foltz *et al.* (1984) revealed several distinguishable strains.

What causes changes in sex ratio and sexuality? Lively (1987) found a correlation between the fraction of males and the number of parasites in New Zealand populations, supporting hypotheses that relate parasites and sex. In Europe, however, males are present but parasites are absent. Further, male frequency appears to increase as population conditions deteriorate.

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SPATIAL AND TEMPORAL PATTERNS OF ABUNDANCE OF THE OLIGOPHAGOUS SACOGLOSSAN HERBIVORE *PLACIDA DENDRITICA*

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The sacoglossan opisthobranch *Placida dendritica* (Alder & Hancock, 1843) feeds on the low intertidal green algae *Codium* and *Bryopsis.* The patterns of *Placida's* abundance on *Codium setchellii* Gardner were monitored from 1985 to 1987. *Placida* appeared on the alga in April and persisted until September/October along the central coast of Oregon. *Placida*'s abundance varied both spatially (between sites) and temporally (between years). *Placida* was less abundant at sites with heavy sand scour and burial than at adjacent areas with low sand impact. Between-site differences in wave exposure were not strongly associated with variation in *Placida's* abundance; differences in algal host density, however, were important. Results from laboratory feeding experiments indicated that *Placida* preferred algae from sites with low sacoglossan abundances: thus differential algal attractiveness did not explain large-scale patterns of sacoglossan abundance.

COMMENSAL LEPTONACEAN BIVALVES OF HONG KONG

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and

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Field observations of intertidal habitats have uncovered several commensal relationships between bivalves and invertebrate hosts in Hong Kong. Twenty-one species of Leptonacea have been collected, representative of the Lasaeidae, Kellidae, Montacutidae, and Galeommatidae.

Species of *Pseudopythina* were found in the burrows of holothurians, sipunculans and echiurians, and attached to the carapaces of decapod crustaceans and the abdomen of stomatopods. Method of attachment varied between species with two attached directly to the host by a byssus, one grasping the host with the anterior margin of the shell, and three living unattached in the host burrow. At least two new species of *Pseudopythina* have been discovered.

An unidentified and possibly new species of *Scintillona* has been recorded byssally attached to the heart urchin *Brissus latecarinatus.* As previously reported from Japan, *Entovalva semperi* was found associated with the burrowing holothuroid *Protankyra bidentata.*

Hosts are not discernible for the many of the rock dwelling bivalves, including some species of *Lasaea, Kellia, Scintilla, Galeomma*, and *Mysella.* Four species of *Scintilla* and *Galeomma* live under intertidal rocks and are commonly found with alpheid shrimps, but a direct commensal relationship between bivalve and crustacean has yet to be established. Similarly, several other leptonaceans, including species of *Ephippodonta, Scintilla*, and *Mysella*, are found in coral galleries with alpheid shrimps.

LIFE HISTORY OF THE INTERTIDAL CALIFORNIAN NUDIBRANCH *HOPKINSIA ROSACEA* MACFARLAND, 1905

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The population dynamics of *Hopkinsia rosacea* (Nudibranchia: Goniodorididae) were studied over a 7 year period at Cabrillo National Monument, on the southwestern tip of the Point Loma peninsula (32° 40′ N; 117° 14′ 37″ W), San Diego, California. Population reconnaissance and measurements were made year-round at low tide periods.

The majority of the observed nudibranchs (61%) occurred underneath rocks and on their bryozoan prey item, *Eurystomella bilabiata* (Hincks, 1884); 13% were underneath rocks but not actually resting on their prey; the remaining 26% were not under rocks, but were in varying degress of exposure. Of those not underneath rocks, approximately two-thirds were found floating upside down at the surface of the water, during the May and June dawn low tides (this floating may be associated with the reproductive cycle of the species, because at other times of the year this behavior was infrequent).

This intertidal species has an annual cycle, with maximum adult size reached from April to July. Very small individuals of the new generation appear in late fall, growing throughout the winter and spring.

Reproductive behavior (egg laying) was most pronounced during March to June.

THE SHAPE OF *TESSAROLAX*, AN UNUSUAL LATE CRETACEOUS GASTROPOD

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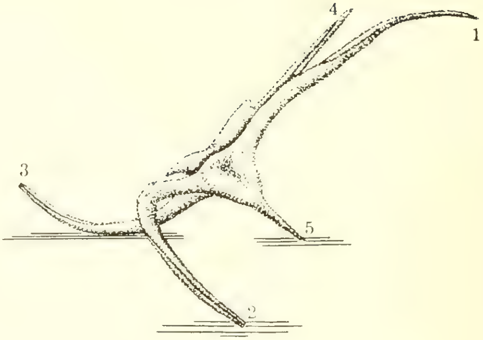
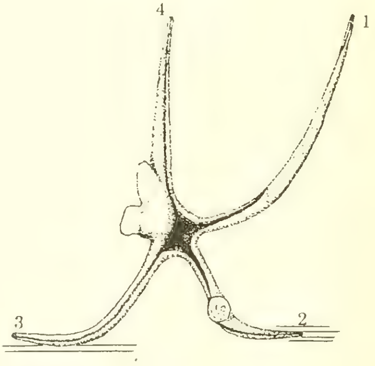
Characteristic morphology can now be described for typical *Tessarolax* Gabb, 1864, based on more complete specimens, especially of *Tessarolax incrustata* Anderson & Hanna, 1935, of early Maastrichtian age from northern Baja California, Mexico. Gabb based the aporrhain gastropod *Tessarolax* on a specimen of early Campanian (Late Cretaceous) age collected at Tuscan Springs, Butte County, California, from which the labral extensions were broken. Despite the incompleteness of original and subsequent specimens of the type species, *Tessarolax distorta* Gabb, 1864, the genus has been recognized in Europe, India, and Japan.

Tessarolax has four long curving digitations (1-4) extending from its aperture. Two sprout from the outer lip edge; one extends along and beyond the spire, and the fourth engulfs and extends beyond the rostrum. The posterior outer lip digitation (1) slopes toward the substrate, bends posteriorly, and turns away from the substrate near its distal end. The channel along the digitation begins on the apertural side, but migrates to the abapertural side. The distal third of the digitation, but not including the final upward portion, is flattened and appears abraded on the substrate side. The anterior outer lip digitation (2) slopes more abruptly toward the substrate, then more abruptly reverses slope and bends upward. The channel in the digitation begins on the apertural side, runs along the anterior side of the digitation at the bend, then migrates back to the labral side along its upturned portion. A rounded, thick callus pad that is abraded on its substrate side embellishes the bend. The rostral digitation (3) remains nearly in the plane of the shell axis, but distally has a somewhat downward slope. It engulfs the rostrum, extends anteriorly, and curves more or less strongly ablabrally. The channel remains on the apertural side of the digitation, and the rostral digitation is not worn, abraded, or flattened. The apical digitation (4) is the shortest of the four labral digitations; it slopes slightly upward at a narrow angle to the shell axis, and its channel remains on the apertural side of the digitation.

In addition to the four labral digitations, the shell has a thick, knob-like to flange-like ablabral callus, a thick tongue of callus that extends along and beyond the spire, and a dorsal projection (5) that arises from the strong anterior rib of the last whorl and forms a relatively straight prong pointing away from the substrate. The entire mature shell is callus coated, and in a shell of approximately 3 cm height the digitation span commonly exceeds 11 cm.





A NEW VERMETID FROM WEST MEXICO

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Fourteen valid species of vermetid gastropods are known from the Panamic marine faunal province, which extends from the southern tip of Baja California, throughout most of the Gulf of California, to northern Peru. This study is about a new vermetid from Isla Isabela, Nayarit, Mexico. The new species is distinguished from other Panamic province vermeted taxa by a calcified operculum, lack of sculptural pattern, and minute adult size. These vermetids were revealed by extensive cleaning of substrate limpets, *Ancistromesus mexicanus* (Broderip & Sowerby, 1829), on which they occur. The type population consists of about 1300 individuals settled gregariously in close association with a coralline alga, *Lithophyllum lichenare* Mason, on the dorsal surface of two *A. mexicanus* specimens.

PATTERNS OF MOLLUSCAN DISTRIBUTION IN EARLY PERMIAN MARINE PALEOCOMMUNITIES, McCLOUD LIMESTONE, NORTHERN CALIFORNIA

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The Lower Permian McCloud Limestone of Shasta County, northern California, represents sedimentary deposition within an island arc terrane. Using sedimentary information only, all collected localities were plotted on shoreline to shelf margin depth transects for two time periods: 1) the first half of the Wolfcampian during which mixed carbonate and clastic deposition occurred on a ramp setting; and 2) the second half of the Wolfcampian during which relatively pure carbonate deposition occurred on a rimmed shelf setting. Subsequent incorporation of paleontologic data reveals the following: 1) proximal ramp/shelf deposits contain moderate diversity, brachiopod-dominated paleocommunities; 2) distal ramp/shelf deposits contain high diversity, gastropod-dominated paleocommunities; and 3) near-shore, marginal marine deposits containing bivalve-dominated paleocommunities are not present in the McCloud Limestone as they are in coeval deposits elsewhere in western North America.

THE APPLICATION OF SCENARIOS TO THE STUDY OF MOLLUSCAN PHYLOGENY

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Biological species and monophyletic taxa are not classes, but "individuals" in a metaphysical sense. By implication, there are no laws of nature for such individuals, although there are laws of nature for classes of individuals.

Laws of nature can be used to test hypotheses in historical biology and paleontology in the same way that they are used to test hypotheses in historical geology. Laws of nature are necessarily true of everything to which they apply, irrespective of time and place. An hypothesis that contradicts a law of nature therefore must be false. Consistency with a law of nature does not, however, imply that an hypothesis is true.

Reconstructions of fossil organisms can be refuted by showing that they contradict some law of nature. Physiology considerably restricts the number of acceptable reconstructions of fossil gastropods, and provides legitimate evidence about their functional anatomy. Because, however, individual taxa are not classes, generalizations about them are contingent facts, not laws of nature, and what is true of presently existing representatives of a taxon may not be true of earlier ones. Therefore the so-called principle of taxic uniformitarianism is not legitimate.

Laws of nature also can be used to test theories about relationships. A maladaptive intermediate is evidence against a theory. Reconstructions of the early stages in the origin of mollusks have been supported by showing that the theory is physiologically plausible. These have been invoked for both the flatworm and the annelid hypotheses of molluscan ancestry. A legitimate criterion for deciding between them is that one of them is implausible, not that either is plausible. The annelid hypothesis is preferable because it requires less extensive convergence both with respect to the traditional data of comparative anatomy and embryology and the latest findings in molecular biology (18S ribosomal RNA sequence data).

THE FAMILY OMALOGYRIDAE IN THE TROPICAL EASTERN PACIFIC

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The genus *Omalogyra* in the family Omalogyridae contains species found in northern Europe, the Mediterranean, West Africa, and from locations on our Atlantic Coast. At least one species is known in the Indo-Pacific, *Omalogyra japonica* (Habe, 1972), which has been reported from Hawaii to Japan.

In 1983 I found a single specimen of a curious, minute, brown shell from Cocos Island, Costa Rica, that was about 0.5-0.7 mm in diameter. Unfortunately, this shell was lost as it was being photographed. Later, I found six specimens of the same species at Guaymas, Sonora, Mexico. All but one of these were later crushed or lost. In 1986, a second specimen was found at Cocos Island, Costa Rica. This past February (1988), Kirstie Kaiser and I found many additional specimens at various collecting stations in the Galapagos and at Cocos Island. It seems to be undescribed.

MOLLUSCAN PALEOECOLOGY OF TWO MARINE PALEOCOMMUNITIES, LOWER CRETACEOUS WALNUT FORMATION, CENTRAL TEXAS

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The Lower Cretaceous Walnut Formation of Central Texas contains prominent oyster packstone biostromes surrounded by skeletal wackestones and mudstones. The biostromes represent a shallow marine paleocommunity dominated by a single oyster species, *Texigryphaea mucronata*. Associated taxa include serpulid worms, membraniporid bryozoans and clionid sponges. The surrounding wackestones /mudstones contain the *Exogyra texana - Heteraster texana* paleocommunity. Dominant species include: the bivalves, *E. texana* and *Protocardia multistriata*; the gastropods, *Tylostoma* sp. cf. *T. chihuahuense* and *Turritella* spp.; the cephalopods, *Oxytropidoceras salasi* and *Engonoceras pierdenale*, and the echinoid, *Heteraster texana*.

In a transect from the more onshore, *Texigryphaea mucronata* paleocommunity to the adjacent, deeper water *Exogyra texana-Heteraster texana* paleocommunity the following paleoecologic trends are observed: 1) species richness increases; 2) percentage of suspension feeding decreases and percentage of detritus feeding increases; 3) percentage of epifauna decreases and percentage of infauna increases; and, 4) percentage of oyster taphonomic feedback (interaction of living organisms with dead skeletal material) decreases.

SEASONAL VARIATION IN REPRODUCTION OF *TRANSENNELLA CONFUSA*

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Since the original species description in 1982, there has been no published study on any aspect of the biology or ecology of *Transennella confusa* Gray, 1982. This small venerid bivalve (7 mm in length) is unusual in that it broods its developing embryos and young juvenile stages in a brood pouch located between the inner demibranch and visceral mass. This species is an asynchronous brooder, i.e., a single brood contains all or most developmental stages.

Through a series of monthly dissections, we documented seasonal variation in fecundity and clutch size structure for a population at Pillar Point Harbor, California. Fecundity is a function of adult size and there was no significant difference among the spring, summer or fall regressions of brood number versus adult length. However, the January and February samples indicate that fecundity levels are substantially decreased in the winter. The size structure of broods also varies seasonally but not in the same fashion as fecundity. The spring samples are dominated by the smallest size class of embryos (75%), this proportion drops to 50% in the summer and fall. In the winter, the largest size classes of embryos make up most of the brood.

We also compared the patterns observed in *T. confusa* at Pillar Point to its sister species, *T. tantilla* (Gould, 1853), at Friday Harbor, Washington. We use these observations and comparisons to make predictions about the relationships between the reproductive biology and adult population dynamics of these two species.

THE ALLOMETRY OF BROODING IN BIVALVES AND THE IMPORTANCE OF SIZE AT FIRST REPRODUCTION

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When examining the allometric relationships between adult size and fecundity in brooding taxa, it is essential to adjust the allometric equation for size at first reproduction (L_1). Neglecting this term in the equation results in overestimating the allometric coefficient and forces the resulting function to pass through the origin of the fecundity versus adult length plot. I demonstrate that in two published studies of brooding bivalves, *Transennella tantilla* (Gould, 1853) and *Lasaea rubra*, the reported allometric coefficients of 3.02 and 2.98 are overestimated by 75% and 200% respectively, simply because L_1 is not included in the allometric equation. Based on the cubic nature of the over-estimated coefficients, both studies infer a volumetric relationship between adult size and fecundity and that brood size is not limited by the surface area of the gill. When L_1 is included in the equation, the resulting funtions provide a better fit to the reported data.

In detailing allometric relationships between brood composition and adult size, it is important not only to consider the absolute number of individuals in any clutch, but also the relative proportion of developmental stages. In another brooding bivalve, *T. confusa* Gray, 1982, I show that although absolute fecundity values may be equal, brood size structure varies.

A PLEISTOCENE SHALLOW WATER MOLLUSCAN FAUNULE FROM KAENA POINT, OAHU, HAWAII

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Pleistocene shallow-water deposits containing molluscan remains are known from at least three islands in the main chain of the Hawaiian Islands (Ostergaard, 1928, 1939) and are best known from the island of Oahu. Stearns (1978) has shown that these deposits can be dated radiometrically and correlated to Pleistocene glacioeustatic sea level changes and/or subsidence.

While on a reconnaissance trip around the northwestern tip of the island of Oahu in July 1986, I examined a fossiliferous deposit near Kaena Point that has yielded a near-shore molluscan fauna. Subsequent collecting at the same locality in June 1988 yielded a greater diversity of mollusks and allowed examination of the geometry of the deposit. The loosely consolidated sand and coquina of this deposit appear to unconformably overlie an older Pleistocene reef that constitutes the present-day solution/wave-cut bench.

Four species of bivalves have been identified: *Chama isotoma* Conrad, 1837; *Periglypta reticulata* (Linnaeus, 1758); *Septifer bryanae* (Pilsbry, 1921); and *Isognomon perna* (Linnaeus, 1767).

Fourteen species of gastropods have been identified: *Turbo sandwicensis* Pease, 1861; *Cellana melanostoma* (Pilsbry, 1891); *Nerita picea* (Recluz, 1841); *Dendropoma gregaria* Hadfield and Kay, 1972; *Serpulorbis variabilis* Hadfield and Kay, 1972; *Hipponix*

(Antisabia) foliaceous (Quoy and Gaimard, 1835); *Siphonaria normalis* Gould, 1846; *Cypraea caputserpentis* Linnaeus, 1758; *Cypraea mauritiana* Linnaeus, 1758; *Cypraea tessellata* Swainson, 1822; *Cypraea carneola* Linnaeus, 1758; *Conus abbreviatus* Reeve, 1843; *Conus virgo* (Linnaeus, 1758); and *Drupa morum* Roding, 1798.

Many micromollusks have been recovered from the enclosing matrix, including: *Caecum septimentum* de Foin, 1867; *Balcis brunnimaculata* Kay, 1979, and *Triphora* spp.

All of the identified species are still living in the waters of Oahu, except for the limpet *Cellana melanostoma*, which is restricted to the Leeward Islands in the Hawaiian Archipelago. The molluscan fossils recovered from this deposit range bathymetrically from intertidal to shallow subtidal depths (Kay, 1979). Additional components of the faunule include scleractinian corals, benthonic foraminifera, coralline algae, and echinoid spines. The well-sorted, angular, medium- to coarse-grained carbonate sand that comprises the bulk of this deposit is also indicative of a near-shore, shallow water depositional environment. The shallow water origin of this deposit is supported by: 1) bathymetric ranges of the molluscan taxa, 2) sedimentologic characteristics of the enclosing matrix, and 3) geologic setting; there is no evidence of major uplift in the Hawaiian Islands that could have raised deeper water deposits to the present location.

Evolutionary mechanisms similar to those affecting the molluscan fauna of the Galápagos Islands (James, 1984) are likely to be important factors influencing the molluscan fauna of the Hawaiian Islands, although increased geographic isolation in the latter case could affect the magnitude of evolutionary divergence. Comparison between the late Cenozoic molluscan faunas of Galápagos and Hawaii would provide a revealing look at insular molluscan evolution.

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MINUTES OF EXECUTIVE BOARD MEETINGS

Meeting called to order by President M. James at 4:30 p.m., 18 July 1988. Present were M. James, R. Anderson, K. Kaiser, H. Chaney, J. McLean, C. Hertz, V. Kenk, W. Emerson, Wm. & L. Pitt.

After considerable discussion, L. Pitt moved to draft a petition stating our concern that the Board of Trustees of the San Diego Society of Natural History honor the wishes of Dr. Joshua L. Baily, Jr., and to urge the board to immediately establish a Curatorship of Mollusks and have it be known as the Joshua L. Baily Chair of Malacology. The motion was 2nd by R. Anderson and passed with C. Hertz abstaining.

MSP to circulate the petition at the 7:30 gathering the same evening and throughout the annual meeting sessions. Also to have the Secretary send copies with a cover letter to all members and to the Board of Trustees of the San Diego Natural History Society.

Meeting, Part II, called to order by M. James at 4:45 p.m., 19 July 1988. Present were M. James, R. Anderson, K. Kaiser, H. Chaney, C. Hertz, V. Kenk, Wm. & L. Pitt.

Secretary's Report: Summarized by K. Kaiser.

MSP to accept the minutes as summarized.

Treasurer's Report: H. Chaney reported the WSM's approximate net worth as of July 15, 1988 to be $8,232. Membership is up by 27 new members. The total is 222.

MSP to accept the Treasurer's report as given.

Chaney calculated the actual cost per member is slightly over $15 per year and proposed a dues increase for 1990.

MSP. A vote for a dues increase in 1990 be brought to the general membership this year.

MSP. Dues for 1990 will be as follows if accepted by the general membership:

Regular membership	$15.00
Student membership	6.00
Additional family membership	2.00

After considerable discussion as to how costs could be cut it was suggested that the Annual Report must be held to budget.

MSP. The editor will operate within his/her budget and will require two written bids from printers to be transmitted to the Treasurer prior to printing.

Student Grant: V. Kenk reported that 1989 will be the next Student Grant Award year. She accepted the offer to continue chairing the committee, and reported that 18-27 applications are received each year for grants. After a question regarding grant size Kenk suggested that several smaller grants were better than one large one. C. Hertz suggsted that the student winner be encouraged to include their paper in the Annual Report.

Chaney assured Kenk that funds will be available for the 1989 grant through donations and the annual auction proceeds. He reiterated the grant amount remains

at $500 but may possibly be increased to $750 for 1989.

Pitt asked to table the amount of the Student Grant until after the 1988 auction.

Continuation of Executive Board Meeting, Part III, called to order by M. James at 7:25 a.m., 21 July 1988. Present were M. James, R. Anderson, K. Kaiser, H. Chaney, C. Hertz, Wm. & L. Pitt, J. McLean.

Nominations of Officers for 1988-89: C. Hertz, Chair of the Nominating Committee, presented the slate of officers recommended by the committee as follows:

President	Hans Bertsch
1st Vice President	Roland Anderson
2nd Vice President	Paul Scott
Secretary	Kirstie Kaiser
Treasurer	Henry Chaney
Members-at-Large	Bertram Draper LouElla Saul

MSP to accept slate of officers as read.

1989 AMU WSM Report: All is going well with the planning of the joint meeting in Los Angeles June 25-30, 1989.

The WSM will have their annual auction and all proceeds will remain at their discretion.

The logo is being designed with equal billing for AMU and WSM.

All registration money will go into one account and all annual meeting expenses will be paid from this account. C. Hertz questioned if the WSM would be responsible for one of the two symposia. McLean stated that all symposium leaders are west coast people and that it would be a joint venture.

Publicity coordination was a point of concern. McLean assured he would do all publicity for 1989.

Glass Case: A single glass display case will be brought to Los Angeles in 1989 to be used and then offered to the general membership for $75.

There being no further business, the meeting was adjourned at 8:15 a.m. These minutes were respectfully submitted by Kirstie L. Kaiser, Secretary, and approved by Matthew J. James, President.

SUMMARY OF MINUTES OF ANNUAL BUSINESS MEETING

Meeting called to order by President Matthew James at 4:03 p.m., 21 July 1988. 25 members were present.

Secretary's Report: Secretary Kaiser summarized the minutes of the 1987 Annual Business Meeting.

Treasurer's Report: Treasurer Chaney reported the approximate net worth to be $8,232. Membership is up by 27 which brings the total membership to 222. Auction and reprint sale for 1988 totaled $857.

Election of Officers for 1988-89: Carole Hertz, Chairman of the Nominating Committee, presented the following slate of candidates for office:

President	Hans Bertsch
1st Vice President	Roland Anderson
2nd Vice President	Paul Scott
Secretary	Kirstie Kaiser
Treasurer	Henry Chaney
Members-at-Large	Bertram Draper LouElla Saul

Nominations were closed, and the candidates were accepted as presented by acclamation.

Committee Appointments: President James announced the following appointments:

Audit Committee	Dr. Donald Shasky (Chair) Dr. George Kennedy Mr. William Pitt
Student Grant Committee	Dr. Vida Kenk (Chair)

1989 AMU WSM Annual Meeting:

After considerable discussion involving WSM members and new Presidents James McLean and Hans Bertsch, Matt James complimented McLean on his efforts of making the 1989 meeting a joint meeting in fact and spirit. H. Chaney suggested that in order to encourage COA members to stay over for AMU/WSM one week longer by having workshops planned in the evenings.

Dr. Shasky recommended that all auction information be separated and highlighted from the general information that will be sent out prior to the 1989 meeting.

1988 Best Student Paper Award: Michael P. Russell, Department of Paleontology, University of California, Berkeley, was the 1988 recipient for his paper; the Allometry of Brooding in *Transennella* Revisited.

Dues Increase: Treasurer Chaney reported on the need for a dues increase (see Executive Board meeting report). After a positive discussion an increase to $15 per year was suggested and will be voted on in Los Angeles for the following year.

Annual Report: Editor Bertsch reported three concerns in getting out the Annual Report; quality, time, and cost. He suggested a change in the printer for 1988 because of the delays.

G. Kennedy expressed two concerns— that the quality should be kept as high as possible, and that all abstracts be included in the report for the 1989 meeting.

H. Bertsch emphasized that an abstract (not a program summary) must be submitted to the editor within one month after the meeting in order to be included in the Annual Report.

There being no further business, the meeting was adjourned at 5:25 p.m.

The minutes were respectfully submitted by Kirstie L. Kaiser, Secretary and approved by Matthew J. James, President.

1988-1989
WESTERN SOCIETY OF MALACOLOGISTS OFFICERS AND EXECUTIVE BOARD

President	Hans Bertsch
First Vice President	Roland C. Anderson
Second Vice President	Paul H. Scott
Secretary	Kirstie L. Kaiser
Treasurer	Henry W. Chaney
Members-at-Large	LouElla R. Saul and Bertram C. Draper

SERVICE POSITIONS AND COMMITTEES

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Liaison for 1989 Joint WSM/AMU Meeting	Terrence M. Gosliner, F.G. Hochberg, and George L. Kennedy

ANNOUNCEMENTS OF FUTURE MEETINGS

The 22nd annual meeting of the Western Society of Malacologists and the 55th annual meeting of the American Malacological Union will be a combined meeting, held in Los Angeles, California, 25-30 June 1989.

The meeting site encompasses an area, within short walking distance, that includes the Los Angeles County Museum of Natural History in Exposition Park and the University of Southern California campus. Contributed papers and symposia will be held at the Davidson Conference Center on the campus, and some of the evening programs are scheduled at the Natural History Museum.

Two major symposia are planned: Pelagic Gastropods and the Systematics and Evolution of Western North American Land Mollusks. Scheduled field trips include marine dredging, Pleistocene fossils, scuba, San Gabriel Mountains, and San Clemente Island excursions.

For further information contact A.M.U. President James H. McLean, Los Angeles, CA 90007 (213-744-3377), or W.S.M. President Hans Bertsch, c/o LACM (213-372-4436).

The 23rd Annual Meeting of the W.S.M. will be held on the campus of the University of Washington, Seattle, Washington, 18-22 June 1990. There will be a symposium on the mollusks of Alaska, and the "typical" auction and banquet. Field trips will be held on 22 June to take advantage of some of the lowest tides of the year. Contact Roland Anderson, The Seattle Aquarium, Pier 59, Waterfront Park, Seattle, Washington, 98101 (206-386-4347).

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1987 - 30 September 1988

INCOME

Membership dues	$1,470.00	
Student Grant 1988 Donations	363.00	
Publication Sales	185.96	
Auction and Reprint Sales	865.00	
Interest on Savings Account	217.00	
Conference Fees	6,077.00	
TOTAL INCOME during period		**$9,178.51**

EXPENSES

Annual Report	$2,246.89	
Membership and Fees	37.00	
Deposits for 1989 Joint Meeting	532.00	
Reimbursements to Officers	392.90	
Conference Charges	5,438.98	
TOTAL EXPENSES during period		**$8,644.77**
Net Gain for period		748.29
Beginning balance (1 October 1987)		5,194.65
NET WORTH on 1 October 1988		**$5,996.55**

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THE WESTERN SOCIETY OF MALACOLOGISTS

ANNUAL REPORT
VOLUME 22

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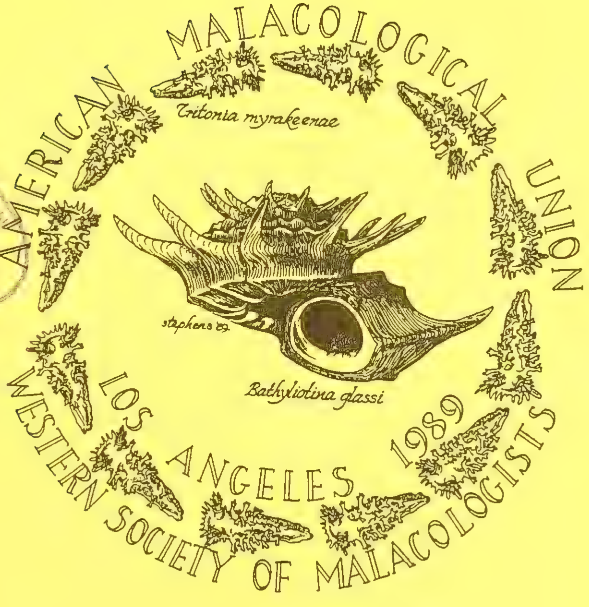

The Western Society of Malacologists

Annual Report

Volume 22

Abstracts and Proceedings of the
Combined Annual Meetings,
Western Society of Malacologists
and
American Malacological Union,
held at Los Angeles, California
25-30 June 1989

Issued:

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Editorial Board, Volume 22
Dr. Hans Bertsch, Editor
Dr. George L. Kennedy

The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the **Annual Report** is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $15.00 for regular members, $17.00 family, and $6.00 student.

The Western Society of Malacologists has issued two **Occasional Papers**—No. 1, "'Sea Shells of Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; and No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan.

Correspondence regarding membership and orders for additional or back issues of the **Annual Report** or the **Occasional Papers** should be addressed to the current W.S.M. Treasurer, Dr. Henry Chaney, 1633 Posilipo Lane, Santa Barbara, CA 93018.

In Memoriam

T.E. Thompson, United Kingdom (31 December 1989)
Eveline du-Bois Reymond Marcus, Brazil (31 January 1990)
G. Alan Solem, United States (26 February 1990)

INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8½" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Research Associate, Dept. Invertebrate Zoology, Los Angeles County Natural History Museum, 900 Exposition Blvd. Los Angeles, California 90007.

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REMARKS ON THE ECOLOGY AND DISTRIBUTION OF SOME GASTROPOD LARVAE FROM THE TROPICAL ATLANTIC

Gotthard Richter
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Senckenberganlage 25,
6000 Frankfurt a. M. 1, F.R.G.

Teleplanic gastropod larvae show remarkable adaptions to the special conditions of pelagic life. In lack of a suitable substratum they can delay their metamorphosis for weeks and months—perhaps years—and so survive even transoceanic transport by relatively slow currents. Such larvae seem to stop feeding and swimming almost completely, but to float, making use of long mucus-threads, drifting in the water.

Another adaption to a prolonged pelagic state represents the cartilaginous larval shell in the genus *Cymatium.* This shell develops from a regular embryonic and post-embryonic aragonite shell, which is transformed into a much more resistant conchyoline one of similar size and shape.

In the tropical Atlantic the main food-source of teleplanic gastropod larvae is dinoflagellates. Larvae from different gastropod families (Thaididae, Cypraeidae, Cymatiidae, Tonnidae, Coralliophilidae, Janthinidae) are able to digest the thick cellulose thecae of these algae, which means exploiting their favorite food-source more effectively. It is remarkable that the occurrence of a cellulase in these cases is restricted to the larval stages, whereas the metamorphosed animals as carnivores have no need of a cellulase.

An unsolved yet very important question is that of the habitat (hatching area), where these larvae came from. The presence of quite small larvae in plankton communities of the Central Atlantic indicates that larvae may reach the area in question in an extremely short time (a few weeks).

BIOLOGY AND DISTRIBUTION OF ATLANTID HETEROPOD MOLLUSCS FROM THE GREAT BARRIER REEF, AUSTRALIA

Leslie J. Newman
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St. Lucia, Brisbane
Queensland, Australia 4067

Atlantid heteropods were collected from surface waters around Lizard (northern Great Barrier Reef) and Heron (southern GBR) Islands from 1985 to 1989. *Atlanta gaudichaudi* Souleyet, 1852, was the most common heteropod within GBR waters. Adults and veligers were found in both sampling seasons (summer and winter). Abundance and species diversity were similar between both islands. Six other species were found in low abundance. Animals were retained in the laboratory for up to one week for feeding studies and observations on veliger metamorphosis. *Atlanta gaudichaudi* selectively preyed on limacinid and creseid pteropods over other zooplankton. Cannibalism on smaller individuals of the same species was common.

Shell surface sculpturing, radula and opercula were examined for taxonomic studies by scanning electron microscopy. All heteropod species collected represented new records or extended distributional ranges for Australian waters.

NET SAMPLING OF HETEROPODS: PROBLEMS AND RECOMMENDATIONS

Roger R. Seapy
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Fullerton, California 92634

The sampling of heteropods by nets is made especially difficult because of low population densities, high patchiness, the microscopic size of the most abundant forms (the atlantids) and potential daytime net avoidance. The design of a sampling program must take into consideration the mouth size, mesh width and filtration properties of the net, the volume of water filtered during each tow, the extent of between-sample (or replicate) variability, and an estimation of the numbers of replicate tows required to adequately sample different heteropod populations. The data for this study come from replicate tow series taken in Hawaiian waters using paired, opening-closing 70-cm Bong nets and an open 4-m^2 ring net.

SHELL GROWTH RATES AND ARAGONITE PRODUCTION OF PTEROPOD AND HETEROPOD MOLLUSCS

Victoria J. Fabry
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

Shell calcification rates of four species of pteropods and two species of heteropods were measured in short-term, ^{45}Ca uptake experiments. In subtropical, temperate and subarctic waters of the North Pacific Ocean and Atlantic Ocean, animals were hand-collected by Scuba divers, captured with the use of a submersible, and caught in plankton nets. Shell growth rates of pteropods and heteropods ranged from 1.1 μg Ca deposited (mg Ca shells)$^{-1}$h^{-1}.

Aragonite production of shelled pteropods and heteropods at three oceanic stations was estimated using the instantaneous growth rate method. Estimates of aragonite production ranged from 2.1 to 6.9 mg $CaCO_3$ m^{-2} d^{-1}.

EVOLUTIONARY CYTOTAXONOMY IN PELAGIC GASTROPODS

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Chromosome number and morphology were given for 6 species of pelagic gastropods: *Hyalocylis striata* (2n=28), *Pneumodermopsis paucidens* (2n=32), *Paraclione longicaudata* (2n=32), *Pterotrachea coronata* (female 2n=32, male 2n=32) *Pterotrachea hippocampus* (male 2n=31) and *Firoloida desmaresti* (female 2n=32, male 2n=31).

Comparison of known karyological data among Thecosomata shows an evolutionary trend from low to high chromosome number suggesting a polyphyletic assemblage, and the possibility of a common ancestor with metacentric chromosomes is discussed. Within the Gymnosomata, the four species studied reveal a chromosomal stability in the chromosome number and a variable proportion of metacentric-submetacentric and subtelocentric-telocentric chromosomes. The chromosome number in Heteropoda is identical to that of known Naticidae, a phylogenetically close family. The presence of sex chromosomes is discussed among the Mesogastropoda.

DISTRIBUTION AND ANNUAL CYCLE OF *LIMACINA RETROVERSA* FLEMING, 1823 IN PATAGONIAN WATERS

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1428 Buenos Aires, Argentina

An annual cycle (April, 1978 - April, 1979) of *L. retroversa* on the Patagonian shelf (40° - 52° S) is analyzed. A stationary distribution pattern is shown in autumn and winter. The shelf population concentrates chiefly in a dense core (max.: 67,800 ind./1,000 m^3) or swarm located to the NW of Malvinas (Falkland) Islands. Individuals expatriated northward connect this core with slope waters and merge with other swarms carried by the eastern branch of the Malvinas Current. In October, the core gradually begins to disintegrate and proceeds slowly northward and off the shelf. The summer distribution pattern consists of scattered individuals on the shelf and some swarms moving along the slope.

Despite the stability of the autumn-winter pattern, the abundance of *L. retroversa* in the area decreases regularly according to the expression:

$$A = e^{33.7667} \quad -0.395006\ m \qquad r = 0.90$$

where A: monthly abundance (ind.); m: month
(April 1978 = 1; April 1979 = 13)

These results are discussed in relation with local hydrology, migration and reproductive events.

MORPHOLOGY OF THE WINGS OF EUTHECOSOMATOUS PTEROPODS

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Zoologisches Institut der Westf. Wilhelms-Universitat
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Using TEM and SEM the morphology and ultrastructure of the wings of several euthecosomatous pteropods were investigated *(Limacina inflata* Orbigny 1836, *Creseis acicula* Rang 1828, *Cilo pyramidata* Linne 1756, *Cavolinia inflexa* Leseur 1813).

The lumen of the wings, which is filled with hemolymph-fluid, is characterized by a framework of smooth muscle cells standing in regular intervals perpendicular to the wing plane. Their dorsal and ventral tips divide into branches (mostly two) before they penetrate the subepithelial muscle layers and insert at the epithelia. Their nuclei are situated in the median wing plane. From the level of the nuclear regions connections between neighbouring muscle cells are found, thus forming rows of perpendicular muscle cells running parallel to the long axis of the wing.

These rows are connected to each other by horizontal branches also originating from the nuclear region sometimes forming a perforated septum in the median wing plane. This horizontal part, whether it may be a septum or a framework of muscle cells, acts as support for nerves, blood vessels and muscle fibres originating from the columellar muscle.

With the exception of a septum a quite similar muscle-framework can also be found in the median footlobe. This gives further evidence for a common origin of foot and wings.

The origin and early morphology of the wings is shown for *Creseis acicula* Rang 1828.

COMPARATIVE REPRODUCTIVE BEHAVIOR OF TWO PELAGIC NUDIBRANCHS, FAMILY GLAUCIDAE

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University of California
Santa Barbara, California 93106

We observed the reproductive behavior and egg laying rates of *Glaucus atlanticus* and *Glaucilla marginata,* two species of pelagic nudibranchs from the Family Glaucidae from eastern Australian waters. Although the same sequence of behaviors occurred in both species to initiate mating and exchange of sperm, the timing of these behaviors was different. The entire process lasted about one hour for *Glaucus atlanticus* and only one minute for *Glaucilla marginata.* This difference in timing appeared to be related to both the morphology of the penis and the number and arrangement of the cerata. Eggs of both species were about the same size, 75 μm by 60 μm. They were enclosed in a membrane and released in a series of discrete strings. The larger *Glaucus atlanticus* had twice as many eggs per string as the smaller *Glaucilla marginata.* Egg laying rates in both species were directly related to food availability, but continued for up to 4 days in the laboratory with little or no food.

RECENT RECORDS OF *PHYLLIROE BUCEPHALA* (GASTROPODA, OPISTHOBRANCHIA) IN THE SUBTROPICAL CENTRAL NORTH PACIFIC

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Phylliroe bucephala were examined from cruises between 1985 and 1988 utilizing the National Oceanographic and Atmospheric Administration sponsored National Marine Fisheries Service R/V *Townsend Cromwell* from the island of Hawaii and the Hancock Sea Mount and from the University of Hawaii R/V *Moana Wave* from around Oahu. Gear included dip nets, drift meter nets, Bongo nets, neuston nets, Isaacs and Kidd midwater trawls and modified Manta nets. *Phylliroe* were absent or scarce except at Hancock Sea Mount where a swarming population was encountered during an eleven day period in January 1988. Eighteen of 73 stations at that location ranged in size from 7 to 28 mm, with a mean of 18.1 mm. They were most abundant between 1830 and 0630 hours.

OBSERVATIONS ON THE ANATOMY OF THE SCAPHOPOD MANTLE

Gerhard Steiner
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Beside *Antalis,* in which the anatomy of the mantle is known, five genera of the order Dentaliida and ten of the Gadilida have been investigated with histological and ultrastructural methods. The anterior mantle edge is divided into functional units: an outer gland region, a central fold, and an inner gland region. Whereas in Dentaliida the outer gland region is prominent and the central fold carries a ciliary organ, the latter is lacking in Gadilida in which only some have glands. *Rhabdus* has a different ciliary organ. The inner gland region consists of different epithelial and subepithelial gland cells in Gadilida; in Dentaliida only the former are present.

The epidermis of the pallial cavity is low but features ciliary rings in the anal region. The posterior pallial edge or pavillon of gadilids has a powerful ciliary organ to produce water currents and ciliated ridges on the dorsal mantle process, both wanting in dentaliids. Different types of gland cells occur in both orders.

Ciliary receptors of both mantle edges are described. Functional and systematic implications are discussed.

STRUCTURE AND FUNCTION OF THE SCAPHOPOD EXCRETORY SYSTEM

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The excretory system of the scaphopods *Dentalium rectius* and *Cadulus aberrans* has been examined with regard to haemocoel, pericardial and nephridial coelom anatomical relationships, the ultrastructural characteristics of ultrafiltrative, reabsorptive and secretory epithelia, and characterization of secretory products. The heart is represented by a peri-anal sinus, which lies adjacent to the pericardial coelom. There is no evidence of a heart enclosed within the pericardial coelom as interpreted by earlier workers. A limited area of the pericardial epithelium, apposing the peri-anal sinus, is developed into prodocytes, and may be the site of primary urine production. The ultrastructure of the scaphopod nephridial epithelium reveals two cell types. The first exhibits extensive vacuolation, within which secretory materials form granules by a process of surface accretion. The second possesses secretory vacuoles which are totally occluded by large granules, and in addition, has a microvillous apical membrane, which may indicate a secondary reabsorptive capacity. Granules in both cell types show a concentric-ring ultrastructure, and are composed primarily of calcium phosphate with a small amount of zinc; there is an organic component of protein, glycogen, and mucopoly-saccharide. Granules are extruded into the nephridial lumen by a process of merocrine secretion, prior to release into the mantle cavity via an externally ciliated, muscular, nephridiopore. While the observed functional morphology is consistent with a generalized plan of molluscan excretion, the scaphopod excretory system also exhibits unique features in circulation/excretion anatomy and secretory cell ultrastructure in comparison to other molluscan classes.

RESOURCE UTILIZATION IN A MULTI-SPECIES SCAPHOPOD ASSEMBLAGE

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The diets of *Dentalium rectius, Pulsellum salishorum,* and *Cadulus aberrans* were determined. *D. rectius* was omnivorous, eating sediment, fecal pellets, foraminiferans, kinorhynchs, and invertebrate eggs. It was most abundant in a silty area that was about 10% organic material by weight, however it was found in all areas examined. It ranged in abundance from about 5 animals/sq. m., in clean sand, to about 66 animals/sq. m. in silt. Foraminiferans were rare where it was most abundant.

Cadulus aberrans was a foraminiferan predator, preying preferentially upon *Cribrononion lene* and *Rosalina columbiana.* The robust foraminiferan species *Elphidiella hannai* was eaten by *C. aberrans* about as often as they were encountered, while the fragile *Florilus basispinatus,* were eaten less frequently than expected. It was found most frequently in an area with sandy sediment that was about 5% organic material by weight. Foraminiferans were common in this habitat. Average densities of *C. aberrans* were about 10 animals/sq. m.

Pulsellum salishorum was a dietary specialist preying on the foraminiferan *Cribrononion lene.* It was distributed evenly, but uncommonly, about 6 animals/sq. m., in all the habitats examined.

ON THE RETENTION OF THE EMBRYONIC SHELL OF *FISSIDENTALIUM PHANEUM* DALL, FROM HAWAII

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Four specimens of the scaphopod *Fissidentalium phaneum* Dall, 1895, that had retained their embryonic shells were dredged in depths of 90 to 180 meters off Oahu, Hawaii. The translucent embryonic shells are approximately 1 mm long with a 0.2 mm long tip formed as a slightly inflated nipple with a small transverse slit in the distal end. Proximal to the inflated tip are several transverse annulations.

Approximately 700 *F. phaneum* specimens without the embryonic shell were obtained in 70 out of 359 sorted dredge hauls taken between 36 an 550 meters off Hawaii, Maui, Molokai, and Oahu Islands, Hawaii, with the greatest number between 90 and 180 meters.

FAMILIAL RELATIONSHIPS AND BIOGEOGRAPHY OF THE WESTERN NORTH AMERICAN AND CARIBBEAN HELICOIDEA (GASTROPODA: PULMONATA)

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Nordsieck's "Revision des Systems der Helicoidea," the latest published classification of the superfamily, is further revised. By showing that anatomical characters of certain Xanthonychid subfamilies are as distinctive as the ones now used to dessignate familial rank for other helicoid families, we reaffirm Schileyko's elevating the Humboldtianinae to familial rank and we propose raising the Helminthoglyptinae, sensu Norsieck, to familial rank. We support the placing of *Monadenia* by Nordsieck into a separate subfamily and we suggest that it belongs in the Bradybaenidae.

The discrete anatomical characters of the American helicoid families and their discontinuous geographical distribution bring into question the theory of a putative continuous radiation and evolution from an Asian origin. Recent geophysical data have shown that large parts of eastern Asia and western America were formed from Gondwanian terranes that migrated tectonically from the South Pacific. We suggest that the helicoid families arrived at their separate destinations, passively, via these Pacific terranes.

TAXONOMIC STATUS AND PHYLOGENETIC CONNECTIONS IN THE HELICOIDEA

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Helicoidea auct. includes the taxa having primarily a dart apparatus. I assume that in an ancestral form there were many aragonite spicules in the vaginal walls; this part of the vagina was connected both spatially and functionally with some mucus tissue originating at the same time above the region. The next stage of evolution— the oligomerization of the number of spicules (future darts) and mucus glands took place and their separation from the vaginal walls in three ways in accordance with the three Recent superfamilies: Helicoidea s. str. (American-European), Hygromioidea (Palaearctic-African) and Xanthonychoidea (Eurasian-American).

The system of American helicoids is as follows.

Helicoidea s. str.: Humboldtianidae (subfamilies: Humboldtianinae, Bunnyinae, Lysinoinae, Leptariontinae, Tryonigeninae subf. nov.).

Xanthonychoidea: Xanthonychidae (subfamilies: Xanthonychinae and Monadeniinae, the former includes the tribes Trichodiscinini, Miraverelliini trib. nov., Xanthonychini, Metostracini); Helminthoglyptidae (subfamilies: Eremariontinae subf. nov., Helminthoglyptinae, Cepoliinae, Micrariontinae subf. nov., Sonorellinae); Epiphragmophoridae.

DISTRIBUTION OF THE BULIMULINAE WITH RELATION TO MICROPLATE TECTONICS

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The Bulimulinae is a subfamily of land snails with a Gondwanaland distribution. They inhabit southwestern and central Australia, the northern tip of New Zealand, the Solomons, the New Hebrides, Fiji, and most of South America. The only exception to this Southern Hemisphere distribution is their occurrence in Central America, the West Indies, and the southern part of North America. One bulimulid genus, *Naesiotus* has a North American -South American disjunct distribution. I propose a model to explain this disjunct distribution in which *Naesiotus* and other bulimulid genera may have been transported on terranes from an origin in what was formerly the South Pacific Ocean or from a continental land mass in what was formerly the Tethys Sea.

COMPARATIVE ANATOMY OF *STERKIA* AND *NEARCTULA* (PULMONATA: VERTIGINIDAE)

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Details of internal anatomy and radulae were analyzed for two relatively unstudied micromollusks in the family Vertiginidae. *Sterkia clementina* (Sterki,

1890) and *Nearctula californica longa* Pilsbry, 1920, were collected from San Clemente Island, California, the type locality. The radula and reproductive anatomy of *Nearctula* are similar to that of *Vertigo*, however sufficient differences exist to merit recognition of *Nearctula* as a valid genus. *Sterkia* has no appendix associated with the penis, therefore we are unable to confirm its previous allocation to the Nesopupinae. *Sterkia* exhibits an affinity for *Opuntia* habitat, whereas *Nearctula* may be found in a wider range of habitats. The distribution of *Nearctula* is restricted to California, Baja California and the California Islands. The distribution of *Sterkia* is distinctly disjunct. A clade of four closely related eastern neotropical species is widely remote from the three western species which mirror the distribution of *Nearctula*.

ZOOGEOGRAPHY OF LAND SNAILS IN THE CENTRAL GREAT BASIN

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The central Great Basin is characterized by high, forested ranges separated by semi-arid valleys. Spring-fed wet meadows or marshes in the valleys support a fauna distinct from that found in the ranges. The dominant fault-block ranges were elevated during the Miocene from a level plain of Oligocene ignimbrites. A few large metamorphic core complexes have had considerable relief throughout the Tertiary.

Sampling of the ranges began in 1976 and continues to date. The known montane fauna consists of twenty-one species, counting the taxonomically difficult *Oreohelix strigosa* and *Oreohelix hemphilli* groups as single species. A minimum of six species in *Oreohelix* brings the total montane fauna to twenty-six. Including the valley habitats, the total known regional land snail fauna is thirty species. Faunal relationships lie with the Rocky Mountain province.

Species-area relationships indicate that the montane faunas are non-equilibrium, undergoing extinction without replacement. This suggests that dispersal of the minute species dominating the fauna is minimal under existing conditions.

UPGMA clustering of the ranges on Jaccard's index suggests that the high ranges of eastern Nevada and adjacent Utah, and those of the western Great Basin form distinct groups. Smaller ranges cluster without regard to geographic relationships, suggesting chance similarities resulting from random loss of species.

HISTORICAL AND ECOLOGICAL ZOOGEOGRAPHY OF THE MOLLUSCS OF THE TEXAS PANHANDLE AND ADJACENT REGIONS

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The living molluscan fauna of the Texas Panhandle includes at least 41 native species whereas Quaternary fossil assemblages from the region contain 142 species. Aquatic environments have changed more during the late Quaternary than terrestrial environments. The modern geographical pattern of increased effective moisture with increased latitude has been present for most, and probably all of the late Cenozoic. Periodic deposition and erosion of extensive riparian terrace systems throughout the Pleistocene have produced a temporary variable system of dispersal routes.

OLIGOCENE LAND SNAILS OF THE ROCKY MOUNTAINS AND ADJACENT AREAS

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Oligocene land snails occur in over 300 localities in the intermontane basins of Colorado, Montana, Wyoming, and the Great Plains of Nebraska and South Dakota. The fauna is poorly known, but includes taxa from at least 13 land snail families. Most of the taxa occur in the earliest Oligocene (Chadronian) rocks, but snails occur throughout the Oligocene sequence.

The Oligocene land snails are largely distinct from their Eocene predecessors, but most are closely related to land snails now living in the western United States and northern Mexico. The most characteristic Oligocene group is the helminthoglyptids that have been lumped in the species "*Helix leidyi.*" These include relatives of *Humboldtiana, Xerarionta,* and *Helminthoglypta.* Other widespread and locally abundant macrosnails include *Polygyrella, Radiocentrum,* and *Ashmunella*-like polygyrids. Rare snails include members of the Ceresidae, Limacidae, Oleacinidae, Urocoptidae, and the last of the Grangerellidae. Oligocene microsnails are very similar to those of the modern Rocky Mountains, and include *Pupoides, Gastrocopta, Vallonia,* and *Discus.*

In local areas, Oligocene land snails can provide detailed biostratigraphies. Over a wide area, land snail faunas of similar ages can be quite different, probably reflecting regional differences in climates during the Oligocene.

POLYGYRID ORIGINS: WEST OR EAST?

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Two conflicting hypotheses have been proposed for the origin and biogeographical history of the North American land-snail family Polygyridae. One postulates the Camaenidae as sister group, with the Ashmunellinae as the most plesiomorphic polygyrid subfamily; the other hypothesizes a non-camaenid holopod as sister group, with the Triodopsinae most plesiomorphic. Based on present distributions, the former hypothesis puts the origin of the polygyrids in the West, and the latter puts it in the East. An attempt will be made to resolve this question, based on anatomical phylogenetics of the Polygyridae and the eight families that have been suggested by various authors as polygyrid close relatives.

A REVIEW OF THE SYSTEMATICS AND BIOLOGY OF *ASHMUNELLA* (PULMONATA: POLYGYRIDAE)

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Species of *Ashmunella* demonstrate considerable overlap in their gross genital anatomy and shell morphology. Little is known of the microanatomy, ultrastructure, and functional morphology of any single species. Dissections of large numbers of individuals from different species groups (Huachuca and Chiricahua Mtns., Arizona; Black Range, New Mexico to date) indicate there may yet be anatomical features useful as systematic characters, the penial morphology and position of the right ocular retractor muscle being examples. Scanning electron microscopy of shell sculpture has proven useful in some cases, particularly among the large toothless forms such as *A. chiricahuana* (Dall), *A. esuritor* Pilsbry, and a Fly Peak population which has been referred to *A. chiricahuana* in the past. A complete description of the reproductive histology of *A. chiricahuana* and *A. proxima duplicidens* Pilsbry has been developed and the ultrastructure of most genital organs of the latter species has been described. Most of the transporting epithelia of the system demonstrates water reabsorption as a principal function. A complete histological picture of the digestive system of at least three species is currently in preparation. SEM preparation of the jaws and radulae of numerous species have provided a useful description but comparative differences have not been useful to date.

CYTOGENETIC STUDIES ON TWENTY-TWO SPECIES/SUBSPECIES POPULATIONS OF *ASHMUNELLA* (MOLLUSCA: PULMONATA: POLYGYRIDAE)

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Studies involving a combination of cytological research tools on species/subspecies of *Ashmunella* revealed that: (1) the subspecies of *A. proxima* are conspecific; (2) *A. angulata, A. chiricahuana, A. ferrissi* and *A. esuritor* are cytologically monophyletic and hence be named the *A. chiricahuana* species group; (3) *A. rhyssa rhyssa, A. r. altissima* and the morphologically intermediate populations are conspecific; (4) the *A. chiricahuana* species group and *A. rhyssa* complex problably share some cytological markers while *A. levettei, A. varicifera, A. mendax* and *A. binneyi* do not. Cytogenetic studies on *A. proxima* X *A. lenticula* F1 hybrids and *A. proxima* X *A. angulata* F1 & F2 hybrids indicated that these are genetically distinct species with incomplete reproductive isolation. Meiotic studies of *A. levettei* X *A. varicifera* F1 hybrids and embryonic survivability of their F2 hybrids point to the conspecific nature of these snails. Therefore *levettei* and *varicifera* should be considered as subspecies of *A. levettei* (Bland).

PRINCE SNAIL: A TSIMSHIAN MYTH

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The study of zoogeography and systematics is colored by one's assumptions. We have been trained to address organisms with the question, "What are you?" When we ask, "Why are you here?", we evaluate the ecological microcosm where the creature lives to learn what led it to reside in such a place. Eventually, we will ask it, "How did you get here?"

For Native Americans, the last question is the only one which needs answering, and the myth of *Prince Snail* provides an eye-opening explanation.

Some might find the Tsimshian view of molluscan distribution funny, even absurd. The evolution of marine snails and chitons from terrestrial ancestors seems implausible to modern scientists. But, such a notion is completely reasonable to a people who employ mythology to explain abstract concepts such as origination.

A REVIEW OF REPRODUCTIVE SYSTEM ANATOMY IN *OREOHELIX*: A PROPOSAL FOR FUTURE RESEARCH

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Because of the apparent "plasticity" of the shell, the environment seems to play an unusually strong role in

determining the shell morphology of *Oreohelix*. This plasticity makes identification of specimens not collected at type localities difficult, if not impossible. For these "cryptic" species, the terminal genitalia have not been particularyly useful. Despite many studies, no species specific characters involving the terminal genitalia have been found. The more recent species description have included a variety of characteristics (e.g. penis anatomy, epiphallus length, insertion of vas deferens into the epiphallus, length of retractor muscle, shape and orientation of the lobes of the ovotestis, plus shell characteristics and locality) which, taken together, usually make species identification possible, although it is a lengthy process. One usually hopes to find a relatively simple process by which to identify species of landsnails. To date, the only sure way to identify the "cryptic" species of *Oreohelix* is to include the use of electrophoresis.

ANATOMICAL OBSERVATIONS OF THE GENUS *HOLOSPIRA* IN ARIZONA, UNITED STATES, AND SONORA, MEXICO

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Preliminary studies of the reproductive anatomies of several *Holospira* species inhabiting Arizona and adjacent Sonora, Mexico, indicate the presence of at least four lineages. These lineages correspond only in part to the described subgenera from this region which are based on shell characters.

The Sonoran species which have been investigated thus far are separable into three distinct lineages based on variations of the structure of the penial complex. One is represented by *H. minima*, the type species of the primary Sonoran subgenus *Allocoryphe*. However, a currently undescribed form whose shell clearly resembles that of *H.* (*A.*) *remondi laevior* differs significantly with regard to the arrangement of the male anatomy and, thus, represents a second lineage (=subgenus?). Another undescribed form which resembles *H.*(*A.*) *dentaxis* exhibits a similar arrangement. The third lineage is represented by *H.* (*H.*) *milleri*.

By comparison, the Arizonan species in subgenera *Eudistemma* and *Holospira s.s.* (in press) are similar to each other with regard to the shape and arrangement of their anatomies and, hence, appear to be a monophyletic group. They differ from the Sonoran species by exhibiting a long, slender epiphallus, a comparatively large, elongate penis and spermathecal diverticulum.

PHYLOGENETIC ANALYSIS OF THE NORTH AMERICAN HAPLOTREMATIDAE (GASTROPODA, PULMONATA)

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The classification of the North American Haplotrematidae (=Haplotrematinae) is revised, based on character compatibility analysis. Two genera are recognized— *Ancotrema* and *Haplotrema*, the latter with three subgenera, *Ancomena, Geomene,* and *Haplotrema, sensu stricto*. The approximate age of the Haplotrematinae is 42.5 Ma (late middle Eocene), when the temperate Haplotrematinae and its tropical out-group, the Austroselenitidae, diverged. The phylogenetic hypothesis indicates an early dichotomy between *Ancotrema* and *Haplotrema*, with the species of *Ancotrema* retaining more characteristics of the common ancestor. Other trends include a tendency toward reduction of vaginal musculature, a parallel tendency toward greater penial complexity, migration of the origin of the penial retractor muscles from the columellar muscle bundle to the floor of the lung (presumably increasing mechanical efficiency), parallel instances of gigantisms in the Pacific Northwest, size reduction southward along the Pacific Coast, correlating with the presence/severity of a summer dry season, and a homoplastic continuation of the loss or reduction of cusps on the teeth of the radula.

EVOLUTIONARY RELATIONSHIPS OF *MICRARIONTA* LAND SNAILS ON SAN NICOLAS ISLAND, CALIFORNIA

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All eleven species of the Quaternary land snail genus *Micrarionta* are restricted to the Southern California Islands. A cladistic analysis of *Micrarionta* species and closely related genera supports the monophyly of *Micrarionta* and indicates that *Eremarionta* is the sister group to *Micrarionta*. Three species endemic to San Nicolas Island, *M. micromphala, M. opuntia,* and *M. sodalis* are a monophyletic group. An excellent fossil record provides clues toward understanding the evolutionary history of these snails. The three species are generally morphologically distinct, and they retained their distinct morphologies when they coexisted in the past, facts supporting their species status. Some geographically-restricted, extinct populations of snails intermediate in morphology between any two of the three species are puzzling because they do not seem to be hybrids or transition forms. Stratigraphic evidence indicates the *M. sodalis* occurred on San Nicolas Island before 120,000 years ago, *Micrarionta opuntia* originated before 18,000 years ago, and *M. micromphala* may have originated near the time *M. opuntia* did, so *Micrarionta sodalis* is probably the direct or indirect ancestor of the other two. An increase in island size due to lowered sea level about the time *M. opuntia* originated may have played a role in a founder-flush type of speciation. *Micrarionta sodalis* became extinct within the last 3500 years. Its extinction may have been influenced by human occupation of the island, or by a preceding period of dry climate.

LAND SNAILS OF NEW MEXICO, COMPARED WITH THE ARIZONA LIST OF BEQUAERT AND MILLER (1973)

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The number of species of native land snails known to occur in New Mexico totals 113, as compared to 128 species recorded by Bequaert and Miller (1973) for Arizona. Nineteen families and 28 genera are common to both states. The family Philomycidae has not been reported for New Mexico nor the family Carychiidae for Arizona. The genera *Chaenaxis* and *Eremarionta* have not been reported in New Mexico nor the genera *Oxyloma, Polygyra,* and *Humboldtiana* in Arizona. Forty-nine species are common to faunas of the 2 states. The genus *Sonorella* is richest in number of species (57) in Arizona, but contains only 5 species in New Mexico. The genus *Ashmunella* comprises 25 species in New Mexico and 6 in Arizona. Some biogeographic relationships of the land snail faunas of New Mexico will be discussed and related to the innovative and comprehensive discussion on the zoogeography of southwestern land snails by Bequaert and Miller (1973). Similarities and differences in the zoogeographic patterns in Arizona and New Mexico will be stressed.

PRESENT STATUS OF THE MICROMOLLUSCS OF NORTHERN SONORA, MEXICO

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The micromollusks of Mexico have received very little attention. Because of their small size they are difficult to see and to collect. Recent explorations have increased our knowledge of the malacofauna of Sonora. While searching for macromollusks several species of microsnails were found at most localities. A total of twenty species has been reported to occur in the state although few habitat accounts are available. Preliminary field work has added new locality records but no new species were discovered. Distribution maps were prepared for each species. The most widely distributed species are *Chaenaxis tuba* (Pilsbry and Ferriss, 1906) and *Gastrocopta pelludica* (Pfeiffer, 1841). A thorough search is still needed to develop more reliable conclusions.

THE NEXT CHALLENGE: LIFE STYLE AND EVOLUTION

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For more than a century, we lucky few have had the fun of going into those hills and, amidst the dust, rocks, heat, spines, and unfriendly arthropods, locating scattered pockets of aestivating land snails. Often they belong to unknown species, sometimes unknown genera.

Described, illustrated, named — then stored in cabinets, accumulated knowledge tells us gross ranges, and treasured bits of collecting lore pass on "how to find" that rarest of the rare, of which Pilsbry (or now Miller) only got five "good adult shells."

How do they survive? What changes in life style and structures have occurred and how can these be correlated with the changes in climate and vegetation that have taken place.

Evidence from a far country is presented to stimulate ideas and suggest future lines of research.

MORPHOLOGICAL AND MOLECULAR GENETIC COMPARISON OF U.S. *HYDROBIA TRUNCATA* AND EUROPEAN *HYDROBIA VENTROSA*

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I't has long been suggested that *Hydrobia truncata* (= *H. totteni*) from northeastern U.S.A. and European *H. ventrosa* were conspecific (Muus, 1967; Bishop, 1976). This contention was strengthened when Oskarsson et al. (1977) found what they identified as *H. ventrosa* on the west coast of Iceland. There is also a strong resemblance between the species in life history and ecology (Davis et al., 1989). Are they conspecific?

Living specimens of *H. ventrosa* from Denmark were studied using tools of detailed comparative anatomy and allozyme molecular genetics. Small but significant morphological differences were found. Twenty-eight presumptive loci and 52 alleles were scored. Nei's (1978) D was 0.259 to 0.289 when *H. ventrosa* was compared with six populations of *H. truncata.* The Cavalli-Sforza and Edwards (1967) arc distance was 0.449-0.473. I conclude that sister species are involved; they are not synonymous.

GENUS *FONTIGENS* PILSBRY (GASTROPODA: HYDROBIIDAE)

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The genus *Fontigens* is a small-sized (8-9 spp.), group widely distributed among aquatic habitats in eastern North America. The genus belongs to the subfamily Emmericiinae Brusina. Congeners are not readily separable by shell alone in some cases, and distinguishing features are also from radula, penis, and pallial oviduct complex. Species may be cave endemic or present in both groundwater and epigean habitat; and include narrowly localized as well as widely distributed forms. The genus is disjunct in distribution, with suites of species largely restricted to

either Ozark Plateau/Central Lowland or Appalachian regions. The relationship between snail zoogeography and modern drainage/physiography is complex.

INTERPLAY OF THE CIRCULATORY AND EXCRETORY SYSTEMS IN BIVALVE FERTILIZATION: EVIDENCE FROM *ANODONTA GRANDIS* (UNIONIDAE)

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Details of the fertilization biology in freshwater mussels are largely unknown. Literature reports and our observations suggest a highly efficient fertilization system in anodontine and lampsiline mussels. To further elucidate the fertilization biology of freshwater mussels, a population of *Anodonta grandis* from the Cedar River, Gladwin County, Michigan was intensively sampled prior to and during the fertilization period in 1985 and 1986. Paraffin cross sections of male and female mussels were stained with hematoxylin/eosin or Feulgen/fast green and subsequently examined for gonad condition and gamete location: Males released spermatozoa in spherical aggregates. In females, spermatozoa were found in the suprabranchial chambers, circulatory system, and excretory system. We hypothesize that spermatozoa are collected by the female's outer demibranchs, internalized to the circulatory system, and subsequently transferred to the excretory system for short-term storage in the distal portion of the nephridium. Eggs released from the gonopore encounter spermatozoa released from the adjacent nephridiopore. If our hypothesis is corroborated, the dependency of fertilization in *A. grandis* on spermatozoa transport within the female circulatory and excretory systems is an unprecedented finding.

NOTES ON CALCIFICATION IN MOLLUSCS: THE PRIMARY FORMATION OF THE NACREOUS SHELL LAYER IN *ANODONTA NUTTALLIANA* LEA, 1838 (BIVALVIA: UNIONIDAE)

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Reported here are data revealing the morphology and chemical composition of micro-spherules discovered in the mantle tissue of the glochidia of *Anodonta nuttalliana* Lea, 1838. These glochidia begin life with only the prismatic layer forming the glochidial shell. Mantle tissue lying against the prismatic layer was found to be charged with numerous micro-spherules. Micro-probe analysis using a LINK Energy Despersive Spectrometer with a Cambridge 360 SEM at 20 kv revealed the presence of hydrocarbons and calcium in both the prismatic layer of the glochidial shell and the micro-spherules lodged throughout the mantle. While the amount of calcium present in the dense prismatic layer was found to be substantially greater than that amount detected in the micro-spherules of the mantle, this is to be expected of the initial stage of crystal formation. The micro-spherules found in the mantle tissue apparently act as "seeds" which will eventually coalesce with growth and form the nacreous inner shell layer.

INDEPENDENT EVOLUTION OF TERRESTRIALITY IN TRUNCATELLID GASTROPODS ON CARIBBEAN ISLANDS (RISSOACEA: PROSOBRANCHIA)

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The phylogeny of the Atlantic Truncatellidae and the origins of terrestrial truncatellids on Caribbean islands were analyzed cladistically using data from morphology, 28S ribosomal RNA sequences, and allozymes. The taxa studied include several terrestrial species from Jamaica and one each from Barbados and Trinidad, and five amphibious species, four from the Western and one from the Eastern Atlantic.

Both anatomy and rRNA sequences support the division of the Truncatellidae into the two subfamilies recognized by Wenz: Geomelaniinae and Truncatellinae. Geomelaniinae includes the terrestrial taxa from Jamaica; Truncatellinae those from Barbados and Trinidad and all the amphibious taxa. I place the terrestrial truncatellines in *Truncatella,* but they are not sister species and so do not share a common terrestrial ancestor. Thus, terrestrial truncatellids evolved at least three times independently from amphibious ancestors in the Caribbean. Jamaica, Trinidad, and Barbados became emergent at various times during the Cenozoic; terrestrial taxa then evolved on each island. Terrestrial truncatellids in the Cayman Islands, Cuba and Hispaniola, and on various Pacific islands may provide additional examples of independent evolution of terrestriality.

Fully terrestrial species have arisen more recently in the Truncatellidae than in other animal phyla. By the early Miocene, some truncatellids had evolved an organizational grade allowing them to readily colonize land in appropriate tectonic contexts. Preadaptations for terrestriality in the family include direct development, resistance to desiccation, feeding on leaf litter, and mode of locomotion. Several characters in transition allow identification of parallelisms such as ctenidial reduction, increased number of whorls, and reduced mucus production. Such transitional stages are likely to have been lost in older lineages; their presence aids phylogenetic analysis of radiations in the Truncatellidae.

HABITAT AFFINITIES AND SPECIES DIVERSITIES OF LAND SNAILS FROM THE RUBY MOUNTAINS, NORTHEASTERN NEVADA

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A total of 14 species of land snails have been identified in 6 habitat types from the Ruby Mountains of northeastern Nevada. These mountains exhibit many complex levels of vegetation and a relatively high annual precipitation. These factors contribute to a high land snail diversity for this range. Relationships between population densities, species diversities, and species assemblages are associated with habitat types and the biogeography of the region. Distribution of all species of snails throughout the range was found to be sporadic in nature, although most species were habitat generalists occurring in 3 or more habitats. Aspen and cottonwood habitats with vegetation structured in 3 distinct substrate levels were found to have the highest snail populations and species diversity. Rock mat communities on dry rocky cliff sites were found to have the smallest populations and species diversity. Geographic variation in shell morphometry was analyzed in populations of *Oreohelix peripherica* and *Oreohelix eurekensis.*

SEASONAL VARIATION IN THE REPRODUCTIVE ORGANS OF TWO POPULATIONS OF THE PULMONATE GASTROPOD *CARACOLUS CARACOLLA* (CAMAENIDAE) IN PUERTO RICO

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Previous studies of the morphology of camaenid pulmonates have indicated that there is a seasonal variation in the reproductive organs of fully mature adult snails. To determine if environmental conditions influence reproductive seasonality, the histology of the reproductive system of two populations of *Caracolus caracolla* (Linnaeus, 1758) were compared. Both populations have different environmental conditions such as temperature and relative humidity. One population of snails was from a rain forest and the other from a dry coastal plain. Four reproductive organs were studied, ovotestis, hermaphroditic duct, spermatheca, and albumen gland. The snails were collected monthly and their organs were dissected, measured (size and weight) and sectioned for microscopical examination. Histological and morphological changes indicate a seasonal variation in the reproductive organs of *Caracolus caracolla* from both populations. Statistical analysis shows a significant difference in almost all of the morphological measurements of the shells and reproductive organs within and between each population. It is possible that the snails from both populations are mating continually throughout the year, since spermatozoa are always present in the hermaphroditic duct. Nevertheless, according to the activity of the spermatheca there are some peaks of mating activity in December for the dry coastal plain population and February for the rain forest population. The mating season was correlated with an increase in temperature and precipitation.

COMPARATIVE SHELL MORPHOMETRICS IN SOME RELATED SPECIES OF FOSSIL AND RECENT *GASTROCOPTA* (PULMONATA: PUPILLIDAE)

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Attempts to identify a fossil species of *Gastrocopta* from the late Wisconsinan, Pleistocene, of Nebraska, using traditional methodology, proved inconclusive. Specimens were compared with Recent *Gastrocopta holzingeri hozingeri* (Sterki, 1889), and *G. holzingeri agna* (Pilsbry & Vanatta, 1948), and the holotype and paratypes of *G. falcis* Leonard, 1946, known only as a Pleistocene fossil from Kansas.

A suite of 32 measurable characters, 20 for the aperture and apertural lamellae and 12 measures of whorl heights and widths, provides a robust data set that completely describes the morphometrics of the pupillid shell. Twenty-two specimens of the four taxa were measured and the data were subjected to principal component analysis with the correlation matrix. Three of the four taxa are separated almost completely in multivariate space defined by the first two principal components.

The analysis suggests that *Gastrocopta falcis* is synonymous with *G. holzingeri,* that *G. agna* is a valid

ECOLOGY AND TAPHONOMY OF ENVIRONMENTALLY STRESSED NON-MARINE MOLLUSCAN POPULATIONS, GRAND PRAIRIE PROVINCE, EAST-CENTRAL TEXAS

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Molluscs of two valleys (with permanent streams) and the intervening divide were studied for two years. The region is underlain by limestone; soil cover is thin or absent, ranging from black calcareous clay of the divides and upper valley sides to fossiliferous, tan, calcareous loams of lower valley side terraces. Divides are covered by grasses, scattered shrubs, and trees, whereas valleys support a dense cover of trees, shrubs and grasses.

Low species diversity is closely correlated with annual distribution of rainfall. Torrential spring rains and rapid run-off produce sheetwash, gulley erosion, and valley flooding which devastate local snail populations. Summer and occasionally longer droughts lead to critical loss of soil moisture and further population stress.

Terrestrial snails of the divide and valleys are consistently active only in the spring and late fall. With cessation of valley flooding in early June and prior to onset of summer drought, a period of 4 to 5 weeks, environmental factors appear uniquely favorable for breeding and reproduction among terrestrial snails. These factors include: 1) rapid plant growth, 2) high soil moisture, 3) daily minimum air and soil temperatures above 60° F, and 4) probable enrichment of near-surface waters in nutrients important to snail development.

Time-averaged death assemblages, living snails, and fossils are transported downstream and deposited together on the valley floor. Such mixed assemblages of aquatic and terrestrial snails, if preserved would convey a confusing picture of the present environmental complex.

EARLY GASTROPODS: NEW TWISTS IN THE TALE

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Recent cladistic analyses of primitive living molluscs (Wingstrand, 1985; Haszprunar, 1988) and new rRNA sequences (Ghiselin, 1988) have pointed to a somewhat segmented ("octomeric"), limpet-shaped, ancestor for all extant snails. The discovery of a variety of unusual limpets in deep-ocean, hot-spring environments has fueled this view, despite the fact that there is evidence for secondary derivation from coiled ancestors (Hickman, 1983).

The Cambrian and Ordovician fossil record provides a fundamentally different picture of the origin and early history of the Gastropoda. Most Cambrian snails are members of an ultradextral clade that disappeared during the Devonian. Late-ontogenetic development of dextral orthostrophy in a latest Cambrian member of this clade could indicate that those living gastropods with heterostrophic larval shells are descended from the Cambrian ultradextral forms. All other gastropods could be independently derived from an early dextral group whose first known member may be the early Cambrian genus *Aldanella*.

MOLLUSCS OF THE IRVINGTONIAN (MIDDLE PLEISTOCENE) SHUTT RANCH LOCAL FAUNA, RIVERSIDE COUNTY, CALIFORNIA

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The Irvingtonian Shutt Ranch Local Fauna, recovered from the Plio-Pleistocene San Timoteo Formation, yielded a malacofauna of 16 taxa, including 2 clams (*Pisidium casertanum* and *P. insigne*), 8 aquatic snails (*Valvata* sp., *Pyrgulopsis* sp., *Fossaria cubensis, F. dalli, Physella concolor, Gyraulus circumstriatus, G. parvus,* and *Menetus opercularis*), and 6 land snails (*Vertigo berryi,* 1 species of Succineidae, *Euconulus fulvus, Pristoloma* sp., *Striatura pugetensis,* and *Deroceras* sp.). The aquatic environment consisted of a spring-fed stream flanked by seasonally varying ponds, all with vegetation rooted in mud beds and banks. The terrestrial environment included a riparian woodland bordered by upland woodland and scrub. The climate was moister, milder, and slightly cooler than today. Dated at 1.3 Ma, the fauna produced the oldest known records for *Striatura pugetensis* and *Vertigo berryi* and the oldest California records for *Fossaria cubensis, F. dalli, Gyraulus circumstriatus,* and *Euconulus fulvus.*

RECORD OF PLEISTOCENE MARINE MOLLUSCS IN THE LOS ANGELES BASIN, SOUTHERN CALIFORNIA, DURING THE LAST MILLION YEARS: AN OVERVIEW

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The Los Angeles Basin, a 50 by 80 km area bounded on the N by the Santa Monica Mtns, on the E by the Elysian, Repetto and Puente Hills, and on the SE and S by the Santa Ana Mtns and San Joaquin Hills, has been the site of continuous subsidence and deposition since the Late Miocene. Quaternary marine and nonmarine sediments in parts of the basin may reach a thickness of 1,300 m. These have yielded the richest and most diverse assemblages of marine mollusks and other invertebrates of any sedimentary basin in western North America. Late Pleistocene mollusks, from the Palos Verdes Sand and equivalents, are best known from exposures along the fringes of the basin (*e.g.*, from Potrero Cyn on the NW, Upper Newport Bay on the S, and Signal Hill and Palos Verdes Hills on the SW). These date to the peak of the last interglacial period (125,000 yrs BP), and are characterized by their warm-water faunal elements. Thirteen marine terraces are present on the Palos Verdes Hills. Faunas from successively higher (older) terraces correlate with successively deeper parts of the surrounding basin deposits. In San Pedro these are represented in part by the highly fossiliferous middle Pleistocene San Pedro Sand (300-350,000 yrs old) and underlying Timms Point Silt (400-500,000 yrs old) and Lomita Marl (500-600,000 yrs old).

FROM TRICHOTROPIDAE TO CALYPTRAEIDAE BY WAY OF *LYSIS* GABB, 1864

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Despite characteristically different shell form the turbiniform trichotropids and limpet-like calyptraeids have been classed (Thiele, 1929) in the gastropod superfamily Calyptraeacea. Ponder and Waren (1988) combine the families Capulidae and Trichotropidae on similarity of soft parts, thereby placing turbiniform trichotropids and cap-shaped calyptraceans in the same family. Fossil evidence suggests that trichotropids and Calyptraeidae are also closely related. Trichotropid gastropods are present in Pacific Slope Cretaceous deposits as early as the Albian (113-97.5 Ma). Undescribed species of both fine-ribbed and coarse-ribbed sculptural types have been found, but only the coarse-ribbed *Trichotropis obstricta* (White, 1889) of Santonian age (87.5-84 Ma) has been described. It has a narrow umbilicus and a somewhat broadened and depressed inner lip. It is readily confused with an undescribed species of *Lysis* that is of Coniacian-Santonian age (88.5-84 Ma). *Lysis* n. sp. differs from *T. obstricta* in having a slightly lower spire, less regularity to the spiral ribbing, a slightly more expanded inner lip, and no umbilicus.

The type species of the genus *Lysis* Gabb, 1864, *Lysis duplicosta* Gabb, 1864, was based on immature specimens collected from a mine shaft at a depth of 40 feet at Texas Flat, near Rock Corral, Placer Co., California. The age of this deposit is imprecisely known, but is probably within the Campanian (84-74.5 Ma). The original description is misleading in stating that there is an umbilicus. Two additional names have been applied to more mature specimens of this species: *Lysis suciensis carinifera* (Whiteaves, 1879), from the Cedar District Formation of mid Campanian age on Sucia Island, San Juan Co., Washington, and *L. opansis* White, 1889, from the Chico Formation of early Campanian age at Pentz, Butte Co., California. *Lysis duplicosta* has a low spire and a rapidly expanding whorl that is angled or biangled at the periphery. Its sculpture consists of 2 to 8 strong spirals, with fine spirals in the interspaces. Both ribs and interspaces are crossed by fine axial imbrications that give the ribs a beaded appearance. The aperture is large, its most striking characteristic is the broad, depressed, concave inner lip that meets the inside of the outer whorl near the suture at a slight groove.

A second Campanian species, *Lysis suciensis* (Whiteaves, 1879), from the Cedar District Formation on Sucia Island (= *L. californiensis* Packard, 1922, from the Williams Formation, Santa Ana Mountains, Orange Co., Caifornia), has fine ribs, a higher spire, and a depressed inner lip that wraps onto the interior of the outer whorl without a groove and extends well beyond the suture. Except for its higher spire, *L. suciensis* bears a strong resemblance to the living calyptraeid *Crepidula grandis* Middendorf, 1849.

Lysis has been variously assigned by different authors to the Stomatellidae, the Fossaridae, the Naticidae, and the Thaididae, but pre-Campanian species are most similar to trichotropids, whereas Campanian species, especially *L. suciensis*, resemble *Crepidula* Lamarck, 1799, of the Calyptraeidae. The very broad, depressed spiraling inner lip of the early Maastrichtian *Lysis intermedia* (Cooper, 1894) is more suggestive of the calyptraeids *Calyptraea* Lamarck, 1799 or *Crucibulum* Schumacher, 1817, than of *Crepidula*. In its coarse ribbing, *Lysis intermedia* is closer to *L. duplicosta* than to *L. suciensis*.

Gabb (1864) described the umbilicus of *Lysis* as "broad, but entirely closed by a concave expansion of the incrusting layer of the inner lip." The inner lip of *Lysis* is, however, better compared to that of *Purpura patula* (Linnaeus, 1758) as suggested by Cox (1925) in describing *Tropidothais*. The broad concave area is not the result of concave expansion of an "incrusting layer," but of a thinning, broadening, and depressing of the inner lip itself back into the shell cavity. Inner lip depression and expansion in *Lysis* suggests that the internal deck, shelf, or septum of calyptraeceans is homologous to the inner lip of trichotropid gastropods.

Pacific Slope species of *Lysis* appear to represent more than one lineage. The presence of fine-ribbed and coarse-ribbed *Trichotropis* and fine-ribbed and coarse-ribbed *Lysis* suggests that species of *Lysis* may have been derived from different tricotropid ancestors and in parallel evolved similar shell form, perhaps as they pursued a similar life style. The facies from which *Lysis* has been recovered suggest that it lived in shallow water, near the shore line. If these gastropods had by Coniacian time become filter feeders, they would have had less need to roam in search of food, and an enlarged aperture would have provided the foot with better access to hard substrates upon which to firmly clamp the shell.

Lysis-like gastropods have been reported from Upper Cretaceous rocks in Africa, New Zealand, Europe, Mississippi, and Japan. Some of these have received generic names. Cox (1925) proposed *Tropidothais* for *T. africana* Cox, 1925, from southeast Africa, which like *Lysis duplicosta* is coarse ribbed. *Damesia* Holzapfel, 1888, based on *Crepidula cretacea* Muller, 1851, from Germany, is more suggestive of a capulid than of a calyptraeid. *Spirogalerus lamellaris* Finlay & Marwick, 1937, from New Zealand, appears to be very similar to *Lysis suciensis*. These similarities require further study to determine whether they result from common ancestry, convergent evolution, or parallel evolution. By whatever path the similarities were achieved, the fossils provide morphological links between turbiniform trichotropids and limpet-like calyptraceans.

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MOLLUSCAN SPATIAL AND TEMPORAL DISTRIBUTIONS: ASSESSING MACROEVOLUTIONARY HYPOTHESES

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The species level properties of geographic range and geologic duration have been used to argue the case for species selection in the molluscan fossil record. Specifically, the empirical correlation between broad geographic ranges and long fossil records in molluscs has recently been given a causal macroevolutionary explanation. If broad geographic range imparts "extinction resistance," and is at least partially heritable in speciation events, then selection should act to preserve species with wide geographic ranges. The observed spatial and temporal distribution patterns of molluscs as revealed in the fossil record is consistent with this macroevolutionary scenario.

In order to critcally evaluate this hypothesis it is imperative not to assess the fossil record uncritically by inferring distribution patterns at "face value." Testing the significance of a positive slope in the regression of geologic duration versus geographic range implicitly assumes that all taxa have an equal probability of being sampled. This implies that for any given time period a geographically short ranging species has the same chance of preservation and discovery as a species with a broader geographic distribution. This assumption is not valid because estimates of species duration are not independent of estimates of geographic range.

Computer simulations of various sampling regimes quantify the degree of autocorrelation between geographic range and geologic duration. The results of these simulations can be used to assess the species selection hypothesis. In addition, I have found a positive correlation between local abundance and geographic range for a sample of 180 species of Recent prosobranch gastropods from the northeastern temperate Pacific Ocean. This implies that geographically restricted species are also locally rare, thus further reducing their chances of being represented in the fossil record and compounding the problem of documenting temporal and spatial distribution patterns.

COMMENTS ON THE "CARIBBEAN ASPECT" OF FOSSIL MOLLUSCS FROM THE GULF OF CALIFORNIA

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Paleontologists have long recognized a "strong Caribbean" component in faunules from the basal Imperial Formation in the Coyote Mts., southeastern California, and from many Tertiary marine formations in west Mexico. All agree that many taxa are "almost the same as" but not conspecific with Caribbean forms. Entirely Caribbean assemblages in west Mexico could imply that the northern Gulf area is a fragment of the Caribbean plate or that a seaway now obscured by the Trans Mexican volcanic arc connected the Gulf of Mexico with the Gulf of California. Neither alternative is suggested by the known patterns of species distributions. Gulf of California assemblages are mixtures of a few conspecific forms with mostly Tertiary-Caribbean descendants and endemic taxa. Fossiliferous sediments associated with radiometrically dated volcanic rocks indicate that seawater was present in the northern Gulf of California by 12 m.y. ago; this is much more time than the 4.5 m.y. previously allowed for the evolution and dispersal of Tertiary Caribbean ancestors in the area. Many biofacies in the northern Gulf have not been recognized outside that area, although an assemblage of *Codakia, Strombus* and *Turritella* from the basal Imperial Formation, Latrania Member, is now also known from the southern Cabo Trough. A period of ca. 8 m.y. is represented near the mouth of the Gulf by an unconformity at the Tres Marias Islands, but in the northern and central Gulf by extensive sedimentary marine sections. Quantifying the Caribbean aspect of west Mexican faunas using percentages of species cannot be undertaken until these vast records are sampled and studied.

A REVIEW OF NORTH AMERICAN CRETACEOUS CYPRAEIDAE AND THREE NEW SPECIES FROM SAN DIEGO AND YOLO COUNTIES, CALIFORNIA

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Cypraeid mollusks are rare in Cretaceous deposits of North America and are represented by six species within the genus *Paleocypraea* s. s., two within the genus *Bernaya* s. s., and six within *Bernaya* (*Protocypraea*). Described species have been found in California, Oregon, Washington, Montana, Texas, Alabama, Delaware, and New Jersey. *Paleocypraea* (*Paleocypraea*) *fontana* (Anderson, 1958) from the Lower Cretaceous (uppermost Lower Albian) Budden Canyon Formation, Shasta County, California represents the earliest cypraeid found in North American strata.

Three new species of Cypraeidae were determined during the course of this study. Two are from the Upper Cretaceous (Campanian/Maastrichtian) Point Loma Formation near Carlsbad, northern San Diego County, and one is from the Upper Cretaceous (Turonian) Yolo Formation, Thompson Canyon, southern Yolo County, California. All three are assigned to the genus *Bernaya* and subgenus *Protocypraea* based upon shell characteristics.

CONSERVATION SURVEY: INVERTEBRATE PALEONTOLOGY TYPE COLLECTION, ACADEMY OF NATURAL SCIENCES, PHILADELPHIA

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The Invertebrate Paleontology Type Collection at the Academy of Natural Sciences consists of nearly 3500 lots, roughly 85% of which are mollusks. Holdings span the Phanerozoic, however the great majority of specimens are from the Cenozoic. Because of the great historical significance of this collection, it was imperative that degradation due to improper storage, handling and environmental control be documented, analyzed and halted. A grant from the Institute for Museum Services (IMS) was obtained in order to have a professional conservator survey the collection, report on current conditions, make recommendations and help formulate a practical conservation plan. The Type Collection was singled out because of its great intrinsic value and because it represents a good sampling of the entire collection in an approachable size. Results of the survey can easily be extrapolated.

Every drawer of the collection was examined and lots representing particular problems pulled for closer study. Problems encountered include: fragmentation, exfoliation, chipping, peeling, coatings, glues, dyes, cracking and contact with archivally unstable housing and labeling materials and mounting media.

Preliminary survey results demonstrate that rehousing the entire collection using archivally stable materials would probably stabilize it. Specimens with serious problems will have to be evaluated and treated on a case-by-case basis.

FIRST REPORT OF THE EOCENE TETHYAN GASTROPOD *VELATES PERVERSUS* IN MEXICO

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Velates perversus (Gmelin, 1791) was a shoreline-dwelling neritid gastropod that had widespread distribution during Eocene time. The species originated during the late Paleocene in the ancient tropical Tethys Sea in a region now known as Pakistan and western India. During the early Eocene (about 55 million years before present), it spread westward from its homeland into Paris Basin, France, and into southern California. Westward dispersal was facilitated by a circum-equatorial current that was present during the early Tertiary. Central America and southern Mexico were submerged. It has been logical to assume that *V. perversus* should be found in Mexico but previously it has not been found there or anywhere in lower Eocene strata between France and southern California.

Based on recent field work by the authors, *V. perversus* can now be reported from the lower Eocene ("Capay Stage") Bateque Formation in Baja California Sur, Mexico, in an area about 75 km southwest of the town of San Ignacio. Numerous specimens were found, ranging in height from 4 to 90 mm and forming a growth series. The specimens change from low-spired naticiform early juveniles to angulate-shouldered young adults to patelliform mature adults, but they are smooth shelled throughout growth. There are seven to eight teeth on the inner lip.

Geologic age of the Bateque Formation was based on planktonic foraminifera, calcareous nannofossils, and the presence of *Turritella andersoni*. The *Velates*-bearing Bateque Formation consists mostly of very fine sandstone interbedded with fossiliferous lenses locally rich in the following shallow-marine organisms: stromatolites, coralline algae, miliolid and discocyclinid foraminifera, three-dimensionally preserved calcareous sponges, colonial corals, and branching bryozoans. The most common bivalves are oysters, with some specimens articulated. The most common gastropods are *V. perversus* and a new subspecies of *Velates perversus* that is ribbed rather than smooth shelled until it reaches the late young-adult growth stage.

The presence of *Velates perversus* in Baja California

Sur helps confirm that the route of dispersal of this species into southern California during the early Eocene was by way of Mexico. The Bateque specimens add a new data point that is 700 km (430 mi) farther south than the previously known early Eocene southernmost limit of *V. perversus* in the Western Hemisphere; namely, the Orocopia Mountains, Riverside County, southern California. A previous report of *V. perversus* in Jamaica is associated with middle Eocene strata.

MARINE GASTROPODA COLLECTED BY THE STEAMER *ALBATROSS* FROM THE PHILIPPINES IN 1908

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During the first year of the 1907-1910 Philippine Expedition of the U.S. Steamer *Albatross,* Paul Bartsch collected numerous molluscan specimens. Included in these were approximately forty species of Velutinacea, Onchidiacea and Opisthobranchia that were richly illustrated by Japanese artist, Kumataro Ito. Unfortunately, attempts to find specimens of this material in the collections of the National Museum of Natural History have been unsuccessful. However, many of these taxa are readily identifiable. Included in these taxa are 2 species of *Scutum,* 3 species of Velutinidae, 1 Onchidiidae, 1 Cephalaspidea, 3 Sacoglossa, 3 Anaspidea, 3 Notaspidea, 26 doridacean nudibranchs, 2 dendronotacean nudibranchs, 3 arminacean nudibranchs, and 1 aeolidacean nudibranch. Included in this collection are drawings of several undescribed taxa, which have now been collected from elsewhere in the western Pacific Ocean.

THE NEW WHITE MICE: *HERMISSENDA* AND OTHER OPISTHOBRANCHS AS BIOMEDICAL MODELS

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The use of the marine organisms including molluscs as model systems for biomedical research has a long and important history. More recently, their usefulness has expanded greatly in the area of neurobiology. The basic advantage inherent to all these animals is their relative simplicity. Their reduced number of neurons which are easily accessible exhibit a high degree of anatomical constancy and homology of function with vertebrates.

Another advantage of marine invertebrates as biomedical research models is their ability to be kept in laboratory culture. Of the molluscs being used, two of the more important species are *Hermissenda crassicornis* and *Aplysia californica.* Both these animals have a record of greater than 20 years of published neurobiological research including behavior, biochemistry, electrophysiology, functional morphology and anatomy of many neural pathways, and laboratory culture. As with the many strains of laboratory mice, rats, etc., laboratory cultures of *Hermissenda, Aplysia* and other opisthobranchs are needed to overcome problems with widely variable performances of field collected animals. Seasonal and other naturally occurring population fluctuations and overcollection pressures also make the natural supply of animals unpredictable. Laboratory reared animals in general have the distinct advantage of being raised healthy and disease free, well adapted for laboratory maintenance, research use, and being continued in specified genetic strains.

POPULATION BIOLOGY OF FLORIDA SACOGLOSSA (GASTROPODA: OPISTHOBRANCHIA)

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Populations of four species were sampled at approximately monthly intervals over multi-year periods, including biomass-specific egg production and alga-specific population density. Three of the species live within a mangrove lagoon in the upper Florida Keys. *Elysia tuca* Marcus was sampled on *Halimeda incrassata,* where the population was nonreproductive and apparently recruited from allochthonous larvae (populations outside the lagoon exhibit an autumnal peak in egg production). *Costasiella* n. sp. lives on *Avrainvillea,* and reproduces all year, with highly variable egg production (no seasonal pattern). *Oxynoe azuropunctata* Jensen exhibits a strong seasonal peak (winter) in egg production, though population density is nearly constant. The reproductive peak may anticipate vernal regrowth of the sole food, *Caulerpa paspaloides.*

The fourth species, *Elysia* n. sp., eats *Caulerpa prolifera* and occurs in the Indian River Lagoon, east central Florida. This species exhibits an irruptive population cycle, reaching very high densities in early summer, followed by precipitous collapse of the population as its food supply disappears.

ADDITIONS TO THE AEOLIDACEAN NUDIBRANCH FAUNA OF THE TROPICAL EASTERN PACIFIC

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The opisthobranch gastropod fauna of the tropical eastern Pacific has been reasonably well studied, particularly from the Gulf of California, Mexico. Included in the species known to occur within the Gulf of California are 16 species of aeolidacean nudibranchs. Recent investigations along the Pacific and Gulf of California coasts of Baja California have provided material of 11 additional species of aeolids, not previously recorded from the region. Four of these constitute new records of described Indo-Pacific species. *Embletonia gracilis* Risbec, 1928, has been recorded from the western Pacific as far east as the Hawaiian Islands. *Phestilla lugubris* (Bergh, 1870) has been recorded from the tropical Indo-Pacific from the east coast of Africa to the Hawaiian Islands. Specimens described from Panama and the Galapagos Islands as *Phestilla panamica* Rudman, 1982, are probably conspecific and represent a junior synonym of *P. lugubris*. The present material constitutes the first record of the species from Baja California. *Eubranchus mandapamensis* (Rao, 1968) has been reported only from the type locality, India, and from Tanzania, though it has also been recently collected from Papua New Guinea and Madagascar as well as the Gulf of California. *Favorinus mirabilis* Baba, 1955, has been recorded from Japan and Australia and has recently been collected from Baja California and the Pacific coast of Central America.

SUMMARY OF THE TAXONOMY AND ZOOGEOGRAPHY OF KNOWN HAWAIIAN CHROMODORIDIDAE NUDIBRANCHS

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Abstract

The geographic distributions of the 23 known species of chromodorids (Gastropoda: Opisthobranchia: Nudibranchia) from Hawaii are given. Only 7 species are currently considered endemic to the Hawaiian archipelago. We report the occurrence of *Glossodoris tomsmithi* and *Chromodoris petechialis* in Guam for the first time, extending their ranges westward more than 2000 and 5500 km respectively.

Although the molluscan fauna of the Hawaiian Islands is the best known of central Pacific islands, the opisthobranch fauna is relatively unknown. Kay (1979) reported approximately 667 species of prosobranchs, 144 species of bivalves, and 137 species of opisthobranchs occurring in this archipelago.

Recently, Gosliner, Johnson & Bertsch (1986) reported 17 species of Indo-Pacific opisthobranchs occurring in Hawaii, in addition to the 137 species reported by Kay (1979). Moreover, they stated that they were aware of at least 93 undescribed species known only from the Hawaiian Islands. Our studies demonstrate there are at least 250 opisthobranch species in the Hawaiian Islands, but a significant portion are still undescribed. Many of these "unnamed endemics" will probably be determined to be wide ranging species throughout the Indo-Pacific faunal region. It is well known that many species that had originally been described as endemic to Hawaii are now reported from elsewhere throughout the Indo-Pacific, or are synonyms of widely ranging Indo-Pacific species.

Our knowledge of the Tahitian opisthobranch fauna represents an interesting contrast. Only about 50 species of opisthobranchs have been reported from the Society Islands (Bertsch, 1988). Most of these species are indigenous to wide areas of the Indo-Pacific faunal province, and are not endemic to the Society Island chain.

Species of the family Chromodorididae exemplify these taxonomic and zoogeographic principles. In 1979, Kay reported 12 species of chromodorids occurring in Hawaiian waters. Although 11 species were originally named from the Hawaiian Islands, she considered only 6 species (50%) endemic. Bertsch & Johnson (1981) illustrated 20 species of Hawaiian chromodorids, of which 9 are known only from the Hawaiian Islands (45%).

The following list summarizes the 23 known species of Chromodorididae that have been illustrated or identified as occurring in the Hawaiian Islands (we have or know of specimens or photographs of additional species, but they have not yet been published). Up to the present, seven of these species (30%) have been reported from only Hawaii (marked with an *).

Ardeadoris Rudman, 1984

* *Ardeadoris scottjohnsoni* Bertsch & Gosliner, 1989
Synonymy: *Chromodoris sibogae* (*non* Bergh, 1905). Bertsch & Johnson, 1981: 49.

Ceratosoma J.E. Gray, 1850

Ceratosoma trilobatum (J.E. Gray, 1827)
Synonymy: *Doris trilobata* J.E. Gray, 1827.
Ceratosoma cornigerum (Adams & Reeve, in Adams, 1848). Kay & Young, 1969: 198-199; Kay, 1979: 466; Rudman, 1988: 135-148 (*q.v.* for complete synonymy).
Geographical Distribution: Throughout the Indo-Pacific region, from East Africa to Hawaii, including the Seychelles, India, Indonesian Archipelago, the Philippines, tropical Australia, New Caledonia and Japan (Rudman, 1988).

Chromodoris Alder & Hancock, 1855

Chromodoris albopunctata (Garrett, 1879)
Synonymy: *Gonidodoris albopunctata* Garrett, 1879.
Chromodoris albopunctatus [sic]. Johnson & Boucher, 1984: 263-4; Kay & Johnson, 1987: 127.
Chromodoris imperialis (*non* Pease, 1860).

Kay & Young, 1969: 202; Kay, 1979: 467, 469; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 48-49, 58-59.

Geographical Distribution: Oahu (Hawaiian Islands), Huahine (Society Islands), Enewetak Atoll (Marshall Islands), and Savo Island (Solomon Islands) (Bertsch & Gosliner, 1989).

Chromodoris albopustulosa (Pease, 1860)

Synonymy: *Doris albopustulosa* Pease, 1860.

Chromodoris albopustulosa. Young, 1967: 168; Kay, 1979: 466-467; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 53; Kay & Johnson, 1987: 127.

Geographical Distribution: Hawaiian and Marshall Islands (Kay, 1979).

Chromodoris aspersa (Gould, 1852)

Synonymy: *Doris aspersa* Gould, 1852.

Chromodoris lilacina (*non* gould, 1852). Kay & Young, 1969: 202-204; Kay, 1979: 467; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 54-55.

Chromodoris aspersa. Rudman, 1983: 145-149 (*q.v.* for additional synonyms); Kay & Johnson, 1987: 127.

Geographical Distribution: widely distributed throughout the Indo-Pacific faunal region (Rudman, 1983).

Chromodoris decora (Pease, 1860)

Synonymy: *Doris decora* Pease, 1860.

Chromodoris decora. Bergh, 1880: 25-26; Kay & Young, 1969: 200-201; Kay, 1979: 467; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 55; Kay & Johnson, 1987: 127; Rudman, 1986 b: 329-333.

Geographical Distribution: Central and western Pacific (including Japan, E. Australia, New Caledonia, Tahiti and Hawaii); Christmas Island (Indian Ocean) (Rudman, 1986 b).

Chromodoris petechialis (Gould, 1852)

Synonymy: *Doris petechialis* Gould, 1852.

Chromodoris petechialis. Kay & Young, 1969: 204-205; Kay, 1979: 468; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 48-49, 108.

Geographical Distribution: Previously reported specimens have been only from the Hawaiian Islands (Figure 1). However, this species has recently been collected in Guam (Bob Bolland, pers. comm.), so we here report for the first time that it is not an Hawaiian endemic. Its occurrence in Guam represents a western range extension of more than 5500 km.

The correct identity of this species is still to be determined.

Chromodoris verrieri (Crosse, 1875)

Synonymy: *Goniodoris verrieri* Crosse, 1875.

Doris marginata Pease, 1860.

Chromodoris marginata (Pease). Kay, 1979: 467-468; Johnson & Boucher, 1983: 267; Kay & Johnson, 1987: 127.

Chromodoris trimarginata (*non* Winckworth, 1946). Kay & Young, 1969: 205-206; Bertsch & Johnson, 1980.

Chromodoris verrieri. Rudman, 1985: 262-267 (*q.v.* for complete synonymy).

Geographical Distribution: Widely distributed throughout the Indo-Pacific, from Tanzania, Enewetak, Noumea, and the Hawaiian Islands (Rudman, 1985).

Chromodoris vibrata (Pease, 1860)

Synonymy: *Doris vibrata* Pease, 1860.

Chromodoris propinquata (Pease, 1860). *fide* Kay, 1979: 470.

Hypselodoris vibrata (Pease). Kay, 1979: 470.

Chromodoris vibrata. Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 56-57; Kay & Johnson, 1987: 127.

Geographical Distribution: Hawaiian Islands; and Enewetak, Marshall Islands (Kay & Johnson, 1987).

Glossodoris Ehrenberg, 1831

* *Glossodoris poliahu* Bertsch & Gosliner, 1989

Synonymy: "Snowflake." Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 59.

Glossodoris rufomarginata (Bergh, 1890)

Synonymy: *Casella rufomarginata* Bergh, 1890.

Chromodoris youngbleuthi Kay & Young, 1969: 206-207; Kay, 1979: 468.

Chromolaichma youngbleuthi (Kay & Young). Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 68-71.

Glossodoris youngbleuthi (Kay & Young). Kay & Johnson, 1987: 127.

Glossodoris rufomarginata. Rudman, 1986 a: 144-148 (*q.v.* for complete synonymy).

Geographical Distribution: Widely distributed throughout the Indo-Pacific faunal region; records include Tanzania; Queensland, Australia; Hong Kong, China; Fiji Islands; and the Hawaiian Islands (Rudman, 1986 a).

Glossodoris tomsmithi Bertsch & Gosliner, 1989

Synonymy: *Chromodoris albonotata* (*non* Bergh, 1875). Bertsch & Johnson, 1981: 52-53; Kay & Johnson, 1987:127.

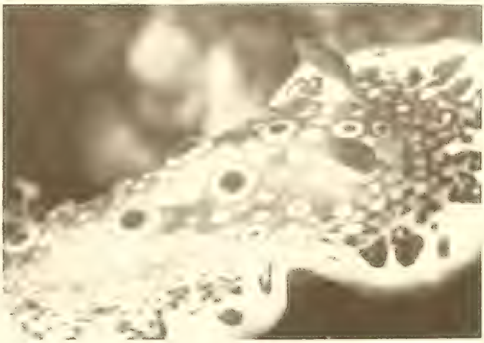

Figure 1. *Chromodoris petechialis*, colleted at Pupukea, Oahu (photo by HB).

Geographical Distribution: In the original description, Bertsch & Gosliner (1989) reported this species from Oahu and Hawaii (Hawaiian Islands), and from Enewetak (Marshall Islands). We here report that *Glossodoris tomsmithi* (Figure 2) also occurs in Guam (Bob Bolland, pers. comm.), a westward range extension of approximately 2000 km.

Hypselodoris Stimpson, 1855

**Hypselodoris andersoni* Bertsch & Gosliner, 1989

Synonymy: "Locust." Bertsch & Johnson, 1981: 66-67, 107.

Chromodorid 1. Johnson, 1983: 356-364.

Hypselodoris maridadilus Rudman, 1977

References: Bertsch & Johnson, 1979: 43; Bertsch & Johnson, 1981: 64; Bertsch & Gosliner, 1989: 250 (*q.v.*for discussion of synonymy).

Geographical Distribution: Eastern Africa, Japan, and Oahu (Hawaiian Islands) (Bertsch & Johnson, 1979).

* *Hypselodoris peasei* (Bergh, 1880)

Synonymy: *Chromodoris peasei* Bergh, 1880.

Doris picta Pease, 1860. Kay, 1979: 470.

Hypselodoris peasei. Kay, 1979: 470; Bertsch & Johnson, 1980.

Hypselodoris cf. *infucata* (Ruppell & Leuckart, 1828)

References: Bertsch & Johnson, 1979: 42-43; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 62-63; Johnson & Boucher, 1983: 271; Kay & Johnson, 1987: 127.

Geographical Distribution: This species is widely distributed throughout the Indo-Pacific. Further work is needed to properly identify the Hawaiian specimens as conspecific with the other populations.

* *Hypselodoris* sp.

Synonymy: *Hypselodoris lineata* (*non* Eydoux & Souleyet, 1852). Kay, 1979: 469; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 65.

* *Hypselodoris* sp.

Synonymy: White dot. Bertsch & Johnson, 1981: 66-67.

Noumea Risbec, 1928

Noumea purpurea Baba, 1949

Synonymy: *Thorunna gloriosa* (*non* Bergh, 1874). Bertsch & Johnson 1981: 60 (top photograph).

Noumea purpurea. Rudman, 1986 b; 311-316 (*q.v.* for additional synonyms).

Geographical Distribution: Tropical Pacific, including Queensland, Australia; Japan; Fiji Islands; Enewetak, Marshall Islands: and Hawaiian Islands (Rudman, 1986b).

Noumea varians (Pease, 1871)

Synonymy: *Chromodoris varians* Pease, 1871

Thorunna gloriosa (Bergh, 1874). Bertsch & Johnson, 1981: 60 (lower photograph).

Noumea varians. Rudman, 1984: 142-145; 1986 b: 316-319.

Geographical Distribution: Christmas Island, Indian Ocean; N. Australia; Guam; Tahiti; Hawaiian Islands (Rudman, 1986 b).

Risbecia Odhner, 1934

Risbecia imperialis (Pease, 1860)

Synonymy: *Chromodoris godeffroyana* Bergh, 1879. Johnson & Bertsch, 1979; Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 48-51; Kay & Johnson, 1987: 128.

Geographical Distribution: Until complete comparisons are made, this species can be positively reported only from Tahiti, Society Islands, and the Hawaiian Islands (and possibly Guam).

The identity and synonymy of this species is currently under review by one of us (Bertsch, in prep.).

Thorunna Bergh, 1877

Thorunna daniellae (Kay & Young, 1969)

Synonymy: *Hypselodoris daniellae* Kay & Young, 1969: 207-209. Kay, 1979: 468.

Babaina daniellae (Kay & Young). Bertsch & Johnson, 1980; Bertsch & Johnson, 1981: 109.

Thorunna daniellae. Rudman, 1984: 221-223. Kay & Johnson, 1987: 128.

Geographical Distribution: Oahu, Hawaiian Islands; and New South Wales, Australia (Rudman, 1984).

**Thorunna nivalis* (*non* Baba, 1937)

Reference: Bertsch & Johnson, 1981: 61.

This is probably an unnamed species.

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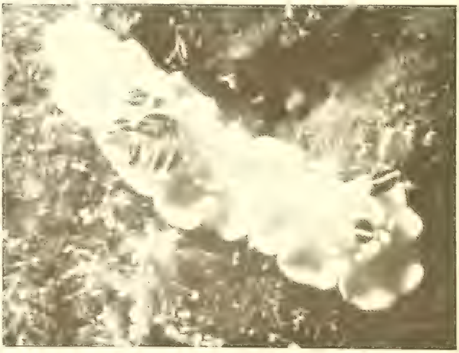

Figure 2. *Glossodoris tomsmithi,* in situ underwater photograph (by HB), 11.5 m deep, at Makua, Oahu.

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ALGAL HOST USE BY THE MARINE SPECIALIST HERBIVORE *PLACIDA DENDRITICA*

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The patterns and consequences of algal host use by marine specialist herbivores are not known. From 1985 to 1988, I examined algal host use by the gregarious sacoglossan *Placida dendritica*. During the spring and summer, *Placida* occurred on 14.5% of the *Codium setchellii* and 71.5% of the *C. fragile* at several sites on the central coast of Oregon. In field transplant experiments, *Codium* density and surrounding algal diversity did not influence *Placida's* abundance. Thus, *Codium* had no low-density or associational escape from *Placida*. Small *Codium*, however, were attacked

less frequently than large ones. *Codium* also had a partial refuge in areas affected by high sand or wave disturbance. *Placida* disproportionately attacked *Codium* stressed by desiccation or damaged by prior *Placida* grazing. Algal damage may be much greater than the amount consumed because *Placida* grazed on strategic algal parts. Thus, the high incidence of *Placida's* attack, coupled with *Placida's* targeted feeding, indicate that the sea slug may reduce survival of its algal hosts.

EVOLUTIONARY HISTORY OF CANTHARIDINE GASTROPODS IN SEAGRASS BEDS

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Evolutionary radiation of taxa comprising the Tribe Cantharidini (Trochidae: Trochinae) has been closely tied to marine plants. A major component of the radiation is in Australian seagrass systems. Seagrass beds have provided a unique set of trophic resources as well as a unique topographic and hydraulic environmental setting for the evolution of peculiar morphological and behavioral innovations.

An initial phylogenetic analysis of relationships of an Australian complex of genera and species is based on a special set of relationships among the axis of shell coiling, the axis of the cephalopedal mass of the animal, and the plane of the substratum. The initial cladistic hypothesis, in which the clines in geometric relationships were directed through outgroup comparison, is subsequently tested by the overlay of four independent sets of data. The hypothesis is supported by (1) the early (Cretaceous) appearance of the plesiomorphic set of conditions and late (Neogene) appearance of the derived conditions, (2) parallel trends in the geometric relationships during ontogeny of the most derived taxa, (3) the correspondence between derived conditions and functional morphological paradigms, and (4) the results of an independent cladistic analysis of a set of 15 anatomical characters directed by separate outgroup comparisons.

ON THE DISTRIBUTION AND MORPHOMETRY OF SOME SPECIES OF *CHICOREUS* (*PHYLLONOTUS*) IN VENEZUELA

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In Venezuela, *Chicoreus margaritensis, Chicoreus* cf. *globosus* and *Chicoreus* cf. *pomum* live on sandy bottoms and *Thalassia* beds, localities that show high densities of *Arca zebra,* and other species of mollusks.

Chicoreus margaritensis has been found living around Cubagua Island, Mochima Bay, Cariaco Gulf and Triste Gulf. Empty shells were recorded at Isla Fernando, Archipelago Los Rogues.

Chicoreus cf. *globosus* has been sampled in Caribe Island, and empty shells were found in some northern Margarita Island beaches and Amuay Bay, Paraguana Peninsula.

Chicoreus cf. *pomum* lives around Margarita Island, Coche Island and Paraguana Peninsula. Empty shells are known from Chirimena beach, Venezuela Gulf and some localities of Cariaco Gulf.

Some individuals of *Chicoreus oculatus* were collected near Puerto Frances and Chirimena beaches and shells were found in dos Mosquices Sur, Archipelago Los Roques.

Due to some individuals of *Chicoreus (Phyllonotus)* species showing highly variable shell characters in different localities, analysis of shell meristic characters and Raupian coiling parameters has been applied to discriminate all their shell forms.

ANATOMY OF *ARCTOMELON STEARNSII* AND *A. BENTHALIS* (PROSOBRANCHIA: VOLUTIDAE): SYSTEMATIC AND ZOOGEOGRAPHIC IMPLICATIONS

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Like most bathyal and abyssal gastropods, both eastern Pacific species of the genus *Arctomelon* Dall, 1915, were described on the basis of empty shells. The genus has been assigned either to the predominantly Japonic and western Pacific subfamily Fulgorarinae, or to the Austral and Magellanic subfamily Zidoninae, as both have superficially similar shell and radular morphologies. Anatomical studies of *Arctomelon stearnsii* (Dall, 1872) and *A. benthalis* (Dall, 1896) serve as the basis of a reassessment of the phylogenetic affinities of this genus. The zoogeography of the bathyal and abyssal volutid fauna of the eastern Pacific is discussed.

ACCESSORY BORING ORGAN (ABO) OF CHILEAN "LOCO," *CONCHOLEPAS CONCHOLEPAS* (MURICIDAE, GASTROPODA).

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The "loco" looks like an abalone, and is the last surviving species of the genus whose other species are recorded only in the fossil record. At least the young bore through the shell of prey (DiSalvo, Biota 1: 14). Arias (Thesis, Univ. of Concepcion, 1983) noted the ABO in the "loco" and urged its study.

Each of three adult snails (kindly shipped by Izador Barrett, Santiago) examined by us possessed a large ABO in the midventral part of the fleshy foot. Histologically, the secretory disc of the mushroom-shaped organ consisted of elongated secretory cells, each with a large ovoid nucleus and an extension to the microvillar border on the free surface of the ABO. The slender ABO stalk contained longitudinal muscle fibres, nerves, and blood vessels in a hemocoel. Histochemically, secretion of the microvillar border was an acidic, non-sulfated mucosubstance with traces of protein.

The ABO of *C. concholepas* morphologically, histologically, and histochemically resembles that of other boring gastropods so far studied (Carriker, Malacologia 20: 403), supporting observations of DiSalvo that it can perforate the shell of prey. Boring is probably a chemical-mechanical process similar to that described for other shell-boring Muricaceans and Naticaceans.

STUDIES ON EGG CAPSULE STRUCTURE, EGGS, EMBRYONIC DEVELOPMENT AND EARLY LARVAL DEVELOPMENT OF *CONUS BILIOSUS* (RODING, 1798) AND *C. CORONATUS* GMELIN, 1791, FROM PAKISTAN

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Breeding season, spawn, egg capsule morphology, egg dimension and number, prehatching development, characteristics and behavior of hatched veliger larvae of *Conus biliosus* (Roding) and *C. coronatus* Gmelin from Pakistan (northern Arabian Sea) were studied. In *C. biliosus* the number of eggs/capsule ranges from 1100-1410 (egg diameter 160-180 μm, incubation period 10-11 days at +32° C, veliger shell length at hatching 210-230 μm). The capsular fluid appears to be nutritive, as the embryos failed to survive after removal from capsule. Previous studies have documented that *Conus* species with large eggs produce large sized larvae with an increased prehatching developmental time. The average egg diameter of both species falls in the modal size class of *Conus* with smaller eggs. Both species exhibit planktotrophic development, characteristic of all *Conus* with large number of small eggs. No nurse eggs were observed; all the eggs in a capsule developed into veligers. Cleavage is holoblastic, with the first two divisions equal, but the third unequal. The larvae were maintained on an algal diet of *Chlamydomonas* and *Navicula* (1:1) and the antibiotic Polymixin B (25 ppm) sea water.

INTRASPECIFIC MORPHOMETRIC VARIATION IN FOUR SPECIES OF ROCKY INTERTIDAL SNAILS FROM DIFFERENT EXPOSURE REGIMES IN HONG KONG

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The correlation between environmental exposure and intraspecific morphometric variation was studied in four species of rocky intertidal snails from the Hong Kong area. Specimens of *Nodilittorina trochoides* (Gray, 1839) *fide* Reid (1988), *Nodilittorina radiata* (Eydoux & Souleyet, 1852) *fide* Reid (1988), *Planaxis sulcatus* (Born, 1780), and *Monodonta labio* (Linnaeus, 1758) were collected from 12 localities which comprised three exposure regimes (High, Moderate, and Sheltered) bsed on coastal morphology and wave action. Each specimen was measured for nine morphological characters with the aid of a Bausch and Lomb digitizing tablet, a WILD M4 compound microscope fitted with a camera lucida, and vernier calipers.

One-way multivariate analysis of variance, performed for each species, demonstrated that the differences in shell morphology were statistically significant (P less than 0.00001) between populations from the three exposure regimes. Stepwise discriminant analyses confirmed that the populations were distinctly different and that the majority (greater than 70%) of specimens were correctly classified into exposure groups. One-way analyses of variance were used to demonstrate possible relationships between exposure and each of the nine morphological characters. The differences in shell morphology are considered to be due at least in part to environmental exposure.

SESSILE SLIT-SHELLS — A FIRST LOOK AT *TENAGODUS* ANATOMY AND BIOLOGY (CERITHIOIDEA: SILIQUARIIDAE).

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Among the non-parasitic gastropod groups that have adopted a sessile mode of life is the poorly known family Siliquariidae, variously linked to either the Vermetidae or Turritellidae.

The genus-group name *Tenagodus* Guettard, 1770, is here accepted as senior objective synonym of *Siliquaria* Bruguiere, 1789.

Clusters of two western Atlantic *Tenagodus* species, *T. modestus* and *T. squamatus*, were found embedded within sponges collected by submersibles in 50-200 m depths off Florida and in the Bahamas.

The anatomy of members of this genus is described for the first time and compared to available data on turritellids, vermetids, and other siliquariid genera. Gross anatomy is found to be very similar to that of turritellids. A number of autopomorphies, such as a large, specialized operculum and a shortened rectum (with the anus in the posterior part of the mantle cavity) can be explained as adaptations in connection with the sessile and embedded mode of life. *Tenagodus* differs in a number of protoconch, opercular, radular and anatomical characters from the previously studied siliquariids *Pyxipoma* and *Stephopoma* (J.E. Morton, 1951).

ANATOMY, REPRODUCTIVE BIOLOGY AND SYSTEMATIC POSITION OF *FOSSARUS AMBIGUUS* (LINNE) (FOSSARIDAE: PROSOBRANCHIA).

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The anatomy of *Fossarus ambiguus* (Linné, 1758), the type species of *Fossarus* Philippi, 1841, was examined for characters diagnostic of the famiy Fossaridae Troschel, 1861. The family is defined by several apomorphic characters: 1) a heavily ciliated cephalic rostrum; 2) a ciliated strip on the dorsal surface of each tentacle; 3) numerous fine denticles on the cutting edge of the lateral radular tooth; 4) a tightly organized nervous system with a very short supraesophageal connective; 5) protandry. The Fossaridae is herein placed in Cerithioidea. Within the Cerithioidea, fossarids are most closely related to members of the Planaxidae. *Fossarus ambiguus* is a protandric hermaphrodite, and constitutes the only known example of this phenomenon among Cerithioidea. *Fossarus ambiguus* has a brood pouch of ectodermal origin from which embryos are released at the veliger stage.

THE SEGUENZIIFORMES, *BASILISSOPSIS* AND *GUTTULA*: WHERE ARE THEY?

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Goryachev (1987) established the order Seguenziiformes for the superfamily Seguenziacea Verrill, 1884, and assigned it to the superorder Littorinimorpha. He also removed *Basilissopsis* to the Trochidae, and erected Guttulidae in the Echinospirida for *Guttula*. This placement and composition of the Seguenziacea conflicts with most treatments published since 1982. Goryachev's analysis of shell, radular, and anatomical characters is examined and compared with other classifications of the Seguenziacea; use of Guttulidae (inae) in Seguenziacea may be warranted.

REPRODUCTIVE SYSTEMS OF NERITIMORPH PROSOBRANCH MOLLUSCS FROM THE EASTERN PACIFIC

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Differences occur in the reproductive anatomy among the eastern Pacific neritimorphan gastropod genera. These differences are based on the location of the accessory sperm sacs in the female, and the nature of the penis in males. Also, there appears to be a direct relationship between the spermatophoric filament and the length of the duct to the receptaculum seminis. In addition, a sorting mechanism has been demonstrated within the crystal sac of *Nerita funiculata*.

PHYLOGENY AND ADAPTATION OF THE PATELLOGASTROPOD RADULA

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In the Patellogastropoda the radular teeth are variable in size and shape in the inner and outer lateral fields. Modification of teeth in the marginal field is not known except in the Lepetidae. A hypothesis of the relationships within the Patellogastropoda was constructed based on an analysis of a data set of over 50 characters. The distribution of radular modifications was then overlain on the resulting cladogram. Based on the hypothesized relationships, the following large scale evolutionary trends in the Patellogastropoda are present: (1) loss of the medially fused inner lateral teeth, (2) reduction in the number of teeth in all three tooth fields, and (3) increasing complexity of the ventral support plates. Morphological adaptations for particular food types are remarkably similar between taxa. Radular adaptations are illustrated and discussed for the following food types: (1) calcareous substrates (e.g., coralline algae), (2) high intertidal diatom flora, (3) marine plants including kelps and angiosperms, and (4) waterlogged wood. When available, the fossil record is used to document the paleogeography and -ecology of specific taxa as well as setting minimum ages for their origin or association with specific substrates.

THE RELATIONSHIP OF ASC'S WORKSHOP ON SYSTEMATICS COLLECTIONS RESOURCES TO NEW NSF INITIATIVES: FUTURE FUNDING OPPORTUNITIES FOR MALACOLOGY

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Last October, the Association of Systematics Collections held a workshop on "Systematics Collections Resources for the 1990's." The workshop covered the status and needs of collections and institutions. It also focused on needs in the areas of computerization and networking. The report was submitted to NSF and was considered by the National Science Board's Committee on Biological Diversity.

The ASC Workshop, the National Science Board Committee's deliberations, and actions of Congress on Biological Diversity have all led to expanded opportunities at NSF for systematics and related activities. New funds are available for computerization projects and conservation biology in the context of a major initiative in Biological Diversity. A new student training program is also being developed. The details of these opportunities and other Federal programs in biodiversity will be reviewed.

THE DICHOTOMOUS KEY AS AN IMPORTANT TOOL IN SYSTEMATIC MALACOLOGY

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Dichotomous keys are a very important tool used in many groups of plants and animals. The usage of keys in malacology is not very extensive, especially in most marine groups. The primary goal of constructing a dichotomous key is to end up with a highly efficient identification tool, but the process of constructing keys is here viewed as an extremely important exercise for the practicing taxonomist. Keys summarize diagnostic characters, and they are a good tool for assessing the composition of taxa. The process of constructing keys forces the taxonomist to critically examine taxonomic characters. Often phylogenetic relationships, parallelisms, and convergences are made obvious during this process. A most important aspect of keys is that they lend themselves to subsequent improvement, and new taxa can easily be added. Additionally, keys can easily be modified for a local fauna. Again, it is the process of constructing keys that is here viewed as of greatest benefit to the taxonomist, with a superior identification tool as a by-product. The construction of a key initially begins with a table of taxonomic characters, from which key characters are carefully chosen. The group is broken down to smaller units by choices of opposing sets of characters: each smaller group is, in turn, further broken down. Key characters of phylogenetic importance are best if they also lend themselves to easy recognition. Once the draft key is completed, testing and subsequent modification follows.

RECRUITMENT OF HARD CLAMS, *MERCENARIA* SPP., IN FLORIDA: WHEN IS REPEATED FAILURE A SUCCESSFUL STRATEGY?

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Commercial landings of *Mercenaria* spp. from the Indian River Lagoon, Florida, increased dramatically in the early 1980's, instigating a research program to examine aspects of the population dynamics and ecology of these bivales. One aspect of this research has involved studying the relationship between *Mercenaria* spp. recruitment and hydrographic, meteorological, and environmental parameters. Results of this work demonstrate that recruitment rates vary spatially within the lagoon (on a scale of kilometers), and that the level of recruitment observed during 1986-1989 has not been sufficient to support a fishery at the level seen in the early 1980's. The broad "failure" of *Mercenaria* recruitment in the lagoon may be a general feature of the Indian River population(s), and, by extension, of other Florida populations. It is probable that massive *Mercenaria* recruitment successes are dependent upon natural climactic events which occur at irregular intervals. Typical levels of recruitment, although considered inadequate by many fishermen, seem to be consistent enough to sustain the population. "Normal" recruitment is spatially variable and probably controlled by settlement patterns and by fluctuations in effects of localized biological disturbances.

LARVAL AND POSTLARVAL SHELL MORPHOLOGY OF *TAGELUS PLEBEIUS* (BIVALVIA: TELLINACEA)

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Several distinct shell morphological features characterize early ontogenetic stages of *Tagelus plebeius* and enable their identification in the plankton and benthos. Adult specimens were collected from mudflats in Delaware Bay, New Jersey, and placed in baywater with 2 x 10^6 cells/ml of microalgae to induce spawning. Disarticulated larval and postlarval shells were examined using scanning electron microscopy.

Larval specimens 110 μm long have small, indistinct provincular teeth. Taxodont dentition is recognizable in shells 115-120 μm long, when 5-7 rectangular teeth are formed in the anterior and posterior regions of the hinge. Provinculum length increases gradually as teeth enlarge with larval development. At a shell length of 166-184 μm, a change in microstructure, marked on the exterior shell surface by a distinct prodissoconch-dissoconch boundary, coincides with settlement and formation of the ligament pit. Postlarval shells 215 μm long have a prominent umbo and an anterior cardinal tooth in both right and left valves. A posterior cardinal tooth forms in the right valve at a shell length of approximately 300 μm and in the left valve at a shell length of approximately 700 μm.

Larvae of *Tagelus plebeius* are distingushed from larvae of several sympatric tellinacean species by their taxodont hinge structure and continuously elongating provinculum; postlarvae are differentiated by the low umbo and absence of cardinal teeth in early stages and finally by the increasingly symmetrical shape of anterior and posterior shell margins.

USE OF GENERAL PROTEIN ELECTROPHORESIS FOR DIFFERENTIATING LARVAL BIVALVES: PRELIMINARY STUDIES OF *CRASSOSTREA VIRGINICA* AND *OSTREA EDULIS*

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Preliminary studies indicate that the electrophoretic profiles of general proteins may be useful as a protein "fingerprint" for identifying larval bivalve mollusks. In this preliminary study, the general protein patterns of larval specimens of *Crassostrea virginica* and *Ostrea edulis* with shell lengths of approximately 200 μm were individually analyzed on thin (0.25 - 0.5 mm) SDS - polyacrylamide slab gels. Three to four electrophoretic bands of single larvae of *Crassostrea virginica* and six to seven bands of single larvae of *Ostrea edulis* were observed after staining with Coomassie blue and / or silver stains. The differentiation of the number and migration patterns of bands provides a potentially powerful tool for the identification of individual specimens of bivalve larvae.

CEPHALOPODS COLLECTED BY THE R/V *DR. FRIDTJOF NANSEN* IN VENEZUELAN WATERS

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The cephalopod fauna of Venezuela is poorly known. Most of the species described are from the northeastern coast and very little is known of the deep sea cephalopod fauna off the Venezuelan coast.

The results of two cruises held during the first two quarters in 1988, revealed the distribution of neritic squids along the coast and of several oceanic species. Specimens were obtained with a bottom trawl of 40 m of sweep area, trawled at depths of 10-650 m. Five epipelagic species, four mesopelagic, two bentholittoral and three mesobenthic were collected.

The epipelagic were represented by *Loligo plei, Loligo pealei, Lolliguncula brevis, Illex coindetti* and *Ornithoteuthis antillarum*; the mesopelagic by *Abralia redfeldi, A. veranyi, Lycoteuthis diadema* and *Pholidoteuthis adami*; the bentholittoral by *Octopus vulgaris* and *O. burryi*; finally the mesobenthic by *Rossia antillensis, Semirossia tenera* and *Nectoteuthis pourtalesi.*

Loligo plei and *L. pealei* were present in 73% of the stations, where the highest yields were obtained in the northeastern continental shelf (x = 26.1 k / h), at depths beyond 60 m in the northwest coast (x = 13.6 k / h) and off the Gulf of Venezuela (x = 17.7 k / h).

Ornithoteuthis antillarum, A. redfeldi, A. veranyi, L. diadema, P. adami, R. antillensis and *N. pourtalesi* are new records for Venezuela.

FIRST REPORT OF CALCIUM MINERALIZATION IN THE STYLETS (SHELL VESTIGES) OF AN OCTOPUS

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Calcium mineralization of the stylets (=shell vestiges) of octopuses of the genus *Scaeurgus* is reported and represents the first record of a calcified internal shell from any octopod, Recent or fossil. The mineralogy of the stylets is determined to be calcite with phosphorous and magnesium. This discovery suggests that the genetic basis for shell mineralization has been conserved in the evolutionary history of the Octopoda despite a generalized reduction in size and loss of mineralization of octopod endoskeletal elements. Functionally, calcification imparts strength and rigidity to the stylets which serve as insertion sites for the paired posterior mantle retractor muscles. Further use of the term "shell vestige" for octopod stylets in general is discouraged.

QUALITATIVE AND QUANTITATIVE ASSESSMENTS OF CONCEALMENT TACTICS USED BY *OCTOPUS BIMACULATUS* IN A KELP HABITAT.

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Octopuses were observed and photographed during the day in their natural kelp habitat off the Channel Islands, California. We assembled an ethogram of body patterns used for concealment, which is their primary defense against predation. We illustrate their tactics of general color resemblance, deceptive resemblance, and disruptive coloration and we then assess pattern and brightness matching to representative backgrounds with a computerized image analyzer. This species is capable of diverse body patterns that proved superb concealment against a multitude of backgrounds; neural control of chromatophores and papillae allow octopuses to conceal themselves instantly as they move onto different substrates. Furthermore, *O. bimaculatus* climbs kelp stalks and remains motionless in a pattern resembling the color, brightness and texture of kelp; this 3-dimensional concealment and foraging tactic has not been observed in other shallow-water, benthic octopods.

MORPHOLOGICAL STUDIES OF PRESERVED OCTOPUSES: A NEW TOOL FOR OCTOPOD TAXONOMY AND SYSTEMATICS

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The soft bodies of preserved octopus specimens vary greatly in texture and consistency. Morphology has been thought to be so variable that measurements can at best only estimate shape. To test this assumption, standard measurements of 7 characters (mantle length, mantle width, head width, arm length, arm width, web depth and sucker diameter) were compiled from literature accounts and directly from specimens for the 10 described shallow water octopods of the western Atlantic.

Within each species, logrithmically transformed measurements of the 6 characters were regressed against mantle length, a measure of body size. If deformation and variation are significant, any correlations will be obscured and show the morphology of preserved specimens to be unreliable. If size-independent morphological variation is minimal, each character will be highly correlated with size, that is, mantle length.

Of the 60 correlations, 55 were significant, 47 significant at $p < .005$. Morphology is reliable despite the soft bodies and apparent deformation of octopod specimens.

The high correlations permit definition and comparison of specific growth trajectories. Further, multivariate analyses discriminate among species groups, based only on these 7 characters, and may provide ecological and phylogenetic information.

NOMENCLATURAL INDEX OF RECENT CEPHALOPOD TAXA

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A data base has been generated of the taxonomic names from family through subspecies levels of Recent cephalopods. Data elements incude the original taxonomic names, author, date, original citation, and type of the taxon (for genus and subgenus). The data base is maintained on an IBM-AT computer using dBASE programs. The system features dual files, the taxonomic data base and the literature citation data base. This enables independent or relational searches and lists to be made. For example, one can determine the author of any taxon, all taxa described by an author, all original species within a genus, all publications by an author wherein new taxa are described, etc. Now that it is established, the system can easily be maintained and updated as new taxa are described.

A NOTE ON THE FECAL ANALYSIS OF *PLEUROBRANCHAEA CALIFORNICA* MacFARLAND, 1966 (OPISTHOBRANCHIA, NOTASPIDEA)

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The feces of thirteen *Pleurobranchaea californica* collected by otter trawl at the sixty meter station in Monterey Bay were analyzed. Eight phyla of prey (protozoa, nemerteans, aschelminths, mollusks, annelids, crustaceans, echinoderms, and fish) were identified in the remains.

SEM AND ENERGY-DISPERSIVE X-RAY MICROANALYSIS OF MURICID PROSOBRANCH RADULAE

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Within the family Muricidae, the gastropod typically perforates the shell of its prey in order to eat its flesh. Relatively small morphological differences in the feeding mechanism might significantly affect the capability of the gastropod to utilize certain species of bivalves as prey. A comparison of the radular morphology with the feeding habits and prey preferences of muricid species presumably would show correlations which reflect the fundamental role of the radula.

The radulae of six locally occuring snails (*Acanthina spirata, Nucella emarginata, Ceratostoma foliatum, Ocenebra lurida, O. atropurpurea, O. interfossa*) were analyzed for elemental composition along the rachidian and lateral teeth.

MICROCOMPUTER-BASED VIDEO MACROPHOTOGRAPHY SYSTEM

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A table-top system for biological recording of high-resolution color images can be assembled entirely from commercially-available, "off-the-shelf" components. The system permits real-time image recording, display, and storage. Components include a charge-coupled device (CCD) camera, video recorder, image capture circuit board, a widely-available microcomputer. The system uses a variety of commercially-available software, and can be assembled with minimal technical skill.

Use of the system will be demonstrated, including "METAZOA" (an image-intensive tutorial for invertebrate zoology), "SLUG-SPEAK" (a pictorial key to sacoglossan molluscs), and various programs for image processing, display and storage.

FEEDING ECOLOGY AND SIZE DISTRIBUTION OF *OLIVELLA BAETICA* (NEOGASTROPODA)

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Olivella baetica were collected in Monterey Bay, California between September and November of 1988 to investigate distribution and feeding preferences. Shell lengths had a bimodal distribution, the two modes being 3.0 and 8.5 mm. This suggested growth of new recruits. Variation was high in the density estimates, ranging from 2 to 17 individuals per 0.1 m. *Olivella baetica* consumed a wider variety of both foraminiferans and other prey items (ostracods, crustaceans, and bivalves) than the larger size classes. Live animals were observed feeding in an aquarium. When food (chopped shrimp) was placed nearby they quickly emerged from the sand, engulfed a chunk of food, and descended beneath the substrate again. Out of forty three snails examined for sex, 91% proved to be male and 9% female. This may reflect differences in distribution or size between the sexes.

MORPHOLOGY OF THE VELUM IN LARVAE OF *ARCHIDORIS PSEUDOARGUS* VON RAPP, 1827 (MOLLUSCA/OPISTHOBRANCHIA)

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The larvae of *Archidoris pseudoargus* von Rapp 1827 is a typical opisthobranch veliger with short planktonic development. It has a realatively simple bilobed velum.

Using a combination of SEM and TEM several types of cells in front and rear epithelium and in the area of the ciliary bands and the food groove can be distinguished. Cells of the two last-mentioned areas contain yolk and pigment granules. The cells of the front and rear epithelia are rich in vacuoles and form a pillow-like surface on each external side.

The whole organ is covered with a brushborder of microvilli. In the food groove these are connected by "discoidal reticulate lamellae" (Bonar & Maugel, 1982). This can be found also on the front surface of the velum, especially between the preoral ciliary band and the inner preoral band, an additional semicircle of cilia on each velar lobe.

Across the velar lumen, which is filled with hemolymph-fluid, fibre-like structures connect front and rear epithelia. They form a web where they are attached to the epithelia. Branches of the larval retractor muscle run through the lumen in radial direction and insert at the rim of the organ.

The pressure of the hemolymph-fluid acts as antagonist to muscles and the fibre-like structures.

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EFFECTS OF INTENSIVE FISHING EFFORT ON THE POPULATION STRUCTURE OF QUAHOGS, *MERCENARIA MERCENARIA* (LINNE), IN NARRAGANSETT BAY, RHODE ISLAND

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Quahogs, *Mercenaria mercenaria* (L.), and sediment samples were collected from three locations in Narragansett Bay: Greenwich Cove, Greenwich Bay, and West Passage. Average density in Greenwich Cove, closed to shellfishing for several decades, was $190/m^2$ (range $32/m^2$-$500/m^2$, 30 quadrats, average valve length [AVL] 62 mm). Greenwich Bay, adjacent to Greenwich Cove and heavily fished since the 1930's, had an average density of $78/m^2$ (range $8/m^2$- $184/m^2$, 30 quadrats, AVL 31 mm). There were no significant differences in crude organic content of sediments between these two sites, whereas a slightly higher content of very fine-grained sands (<125 um), silts and clays in the Greenwich Cove sediments was noticed. The average *Mercenaria* density at another closed site in West Passage was $46/m^2$ with an average valve length of 61mm. The lower density is due to higher silt and clay content of the sediments. There was a significantly higher number of juveniles (<40 mm) in the heavily fished area (p 0.01, ANOVA). Active fishing tends to remove adults from the population and enhance either the set or survival of juveniles. The mechanism for increases in juvenile density is not understood; possible explanations include removal of competition by adults and sediment disturbance/turnover as a result of fishing methods.

MALACOLOGICAL EXPLORATION ALONG THE INNER AND OUTER COASTS OF BAJA CALIFORNIA

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The peninsula of Baja California, Mexico, offers a contrast in terrestrial environments matched by a diversity of marine habitats. Recent expeditions have provided specimens that significantly add to our knowledge of the biodiversity and natural history of the molluscs. The zoogeography of opisthobranchs along both the inner (Gulf of California) and outer (Pacific) coasts involves complex (and at times seasonal) interactions with substrates, available food items, ocean currents, water temperatures, and other factors. Although any single discovery is dependent on the "vagary of the rock roll," predictable patterns of occurrences are now known.

LAND SNAILS OF THE CALIFORNIA ISLANDS

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The islands off California provide a breathtaking natural laboratory setting for studies on the biology and evolution of land mollusks. Although most species were described in the late 1800's they have not been studied in detail until recently. Nineteen species are endemic to the islands. The diversity and density of native snails on several islands is much higher than adjacent mainland areas. Complex distribution patterns often mirror the intrusion of plants and animals from north and south.

ARCHAEOGASTROPOD LIMPETS AT DEEP-SEA HYDROTHERMAL VENTS: A 12-YEAR OVERVIEW OF DISCOVERIES

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Limpets from hydrothermal vents were first collected by using the submersible vessel *Alvin* at the Galapagos Rift in 1977, and in subsequent years at other sites: East Pacific Rise at 21° N, Guaymas Basin, Florida Escarpment, Juan de Fuca Ridge, Mariana Back Arc Basin, East Pacific Rise at 10-12° N, and the Gorda Ridge. French and Canadian submersibles have explored the East Pacific Rise at 13° N, the Juan de Fuca Ridge, Explorer Ridge, and the Mid-Atlantic Ridge.

Limpets in 9 superfamilies and 12 families are known. Five recently described (or currently in press) superfamilies are endemic to the hydrothermal-vent habitat. The endemic groups cannot be derived from existing families. Other living archaeogastropod superfamilies diverged in the late Paleozoic to early Mesozoic; the origin of the endemic hydrothermal vent taxa has to be of similar age. Archaeogastropods dominated the gastropod fauna in the Paleozoic; the unique radular types of the hydrothermal vent archaeogastropods may have occurred in groups that became extinct in shallow water. They may therefore represent living fossils.

ADDITIONS TO THE PANAMIC PROVINCE CHITON (POLYPLACOPHORA) LITERATURE—1971 THROUGH 1988

Reprinted from The Festivus XXI (9): 78-91 (1989).

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The nomenclature for Panamic province chiton taxa has undergone many changes since Thorpe's synopsis in SEA SHELLS OF TROPICAL WEST AMERICA (Keen, 1971). The paper consolidates information published since 1971 so that the references can be easily found and brings the list of species present in the province up to date.

Systematic arrangement follows that of Van Belle (1983) as modified slightly by later authors. Species are listed alphabetically wihin a genus. All species in Keen (1971) are listed and shown with the "Keen number" in brackets after the name. Taxa which differ from those given in Keen (1971) are in bold type. Since the purpose of this paper is to report changes in the literature without being judgmental, synonyms are listed as published by each author, with the exception that those shown in Keen (1971) are not repeated. Where authors disagree, both versions are shown in date order.

The Panamic province, as used by Keen (1971), lies between Magdalena Bay, Baja California Sur, Mexico (about 25° N) and Punta Aguja, Peru (6° S). Seventy-seven species and two subspecies of chitons are currently recognized as occurring in the province. Of the 56 chiton species names originally shown in Keen, only 34 retain species level. Nineteen of the twenty-two new species described since 1971 are considered valid. The remaining species are new to the Panamic province or earlier names not included by Keen.

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Class POLYPLACOPHORA Gray, 1821
Order NEOLORICATA Bergenhayn, 1955
Suborder LEPIDOPLEURINA Thiele, 1910
Family LEPTOCHITONIDAE Dall, 1889
Subfamily LEPTOCHITONINAE Dall, 1889
Genus *Lepidopleurus* (Leach MS) Risso, 1826

Lepidopleurus abbreviatus Dall, 1908. [51]. Becomes synonym of *Leptochiton belknapi*. See number 4.

Lepidopleurus farallonis Dall, 1902. [52]. Becomes synonym of *Leptochiton belknapi*. See number 4.

Lepidopleurus halistreptus Dall, 1902. [53]. Becomes synonym of *Leptochiton belknapi*. See number 4.

Lepidopleurus incongruus Dall, 1908. [54]. Change genus to *Leptochiton*. See number 5.

Lepidopleurus luridus Dall, 1902. [55]. Becomes synonym of *Leptochiton belknapi*. See number 4.

Lepidopleurus opacus Dall, 1908. [56]. Becomes synonym of *Leptochiton belknapi*. See number 4.

1. ***Lepidopleurus scrippsianus*** Ferreira, 1980. Length 20 mm. Off Baja California Sur, Mexico, 2507-2891 m. Previously known only from type lot (Ferreira, 1980). A second specimen from the Eastern Pacific Rise [11° 52′N, 103° 51′W] has been found living on a piece of submerged wood recovered from 2750 m depth (Alvin dive 2000) (D. Eernisse, pers. comm.).

Genus ***Leptochiton*** Gray, 1847
Subgenus *Leptochiton s.s.*

2. ***Leptochiton (L.) albemarlensis*** Smith & Ferreira, 1977. Length 9.8 mm. Isla Isabela, Galapagos Islands, Ecuador, in 20 m. Known only from type lot (Smith & Ferriera, 1977).
3. ***Leptochiton (L.) americanus*** Kaas & Van Belle, 1985. Synonym:*Leptochiton rissoi* of Ferreira, 1981 [not *Lepidopleurus rissoi* Nierstrasz, 1905]. Length to 15 mm. Range: Oregon to southwest of Iquique, Chile, 400 to 1400 m (Kass & Van Belle, 1985a).
4. ***Leptochiton (L.) belknapi*** Dall, 1878. Synonyms: *Leptochiton benthus* Haddon, 1886; *Lepidopleurus mesogonus* Dall, 1902; *Lepidopleurus halistreptus* Dall, 1902; *Lepidopleurus abbreviatus* (Dall) Thorpe in Keen, 1971; *Lepidopleurus halistreptus abbreviatus* Dall, 1908; *Lepidopleurus luridus* Dall, 1902; *Lepidopleurus farallonis* Dall, 1902; *Lepidopleurus giganteus* Nierstrasz, 1905; *Lepidopleurus simplex* Nierstrasx, 1905; *Lepidopleurus opacus* Dall, 1908; *Lepidopleurus japonicus* Thiele, 1909; *Lepidopleurus japonicus aequivalvus* Bergenhayn, 1933; *Lepidopleurus aequispinnus* Bergenhayn, 1933. Length 40 mm. Range: Panama Bay; Galapagos Islands; North Atlantic; Sea of Japan; Bering Sea. Depth: to 550 m (Ferreira, 1979b). Extend range to the Indian Ocean. Add synonyms: *Lepidopleurus similis* E.A. Smith, 1894; *Parachiton opiparus* Iredale & Hull, 1925 (Kaas & Van Belle, 1985a). Holotype of *L. opacus* figured by Smith & Ferreira (1977). Range: the Pacific and Indian Oceans, 160 to 4140 m. *L. alveolus* is restricted to the Atlantic Ocean (Kass & Van Belle, 1987).

5. ***Leptochiton (L.) incongruus*** (Dall, 1908). Length 12 mm. Range: Gulf of Tehuantepec, Mexico; Gulf of Panama. Depth: 589 m (Ferreira, 1979b).

6. ***Leptochiton (L.) nexus*** Carpenter, 1864. Extend range to Bahia de los Angeles in the Gulf of California (Hanselman, 1977). Synonyms: *Lepidopleurus (Xiphiozona) heathi* Berry, 1919; *Lepidopleurus (Leptochiton) ambustus* Dall, 1919; *Lepidopleurus (Leptochiton) lycurgus* Dall, 1919. Length to 25 mm. Range: Alaska to Punta Abreojos, Baja California; Bahia de los Angeles in the Gulf of California, Mexico. Depth: 12 to 90 m (Ferreira, 1979b). Depth: to 144 m (Kass & Van Belle, 1985a).

7. *Leptochiton (L.) rugatus* (Pilsbry, 1892). [1] Add as synonyms: *L. internexus* Carpenter in Pilsbry, 1892; *L. cancellatus* (Sowerby) in Dall, 1879; *Lepidopleurus assimilis* Thiele, 1909; *Lepidopleurus alascensis* Thiele, 1909. Range: Alaska to Bahia Magdalena, Baja California Sur, Mexico (Ferreira, 1979b). Range: throughout most of the Gulf of California, Mexico; Sea of Japan; Okhotsk Sea; Bering Sea. Intertidal to 458 m. (Kaas & Van Belle, 1985a).

Genus ***Oldroydia*** Dall, 1894

8. ***Oldroydia percrassa*** (Dall, 1894). Synonyms: *Hanleya hanleyi* (Bean) in Oldroyd, 1927 [not *Chiton hanleyi* Bean, in Thorpe, 1844]; *Hanleya spicata* Berry, 1919. Length to 28 mm. Range: Salsipuedes Channel, Gulf of California, Mexico; Monterey Bay, California to Isla San Benito, Baja California, Mexico; the Sea of Japan. Intertidal to 457 m (Ferreira, 1979b). Delete *Hanleya hanleyi* (Bean) as synonym and delete the Sea of Japan from the range. Intertidal to 730 m (Kaas & Van Belle, 1985a).

Suborder CHITONINA Thiele, 1910
Family ISCHNOCHITONIDAE Dall, 1899
Subfamily ISCHNOCHITONINAE Dall, 1889
Genus ***Ischnochiton*** Gray, 1847

9. ***Ischnochiton carolianus*** Ferreira, 1984. Length 8.5 mm. Near Bahia San Carlos, Sonora, and at Bahia de los Angeles, Baja California, Mexico. Depth: 61 to 182 m (Ferreira, 1984).

10. ***Ischnochiton** dispar* (Sowerby, 1832). [15]. Change genus (Smith, 1977). Add synonyms: *Gymnoplax anaglyptus* De Rochebrune, 1884; *Lepidopleurus fuscopunctatus* (Carpenter MS) Leloup, 1961 (Kaas & Van Belle, 1980).

11. ***Ischnochiton eucosmius*** Dall, 1919. [16]. Change genus. Add synonym *Radsiella guatemalensis* (Thiele, 1910) (Smith, 1977) (Smith & Ferreira, 1977).

12. ***Ischnochiton macleani*** Ferreira, 1978. Length 5.0 mm. Tagus Cove, Albemarle Island, Galapagos Island. Depth: 55 m. Known only from the Galapagos Islands (Ferreira, 1978).

13. ***Ischnochiton** muscarius* (Reeve, 1847). [17]. Change genus. Range: Guaymas, Sonora, to Salina Cruz, Oaxaca, Mexico (Ferreira, 1983b).

***Ischnochiton** petaloides* (Gould, 1846). [19]. Change genus. Extend range south to the Galapagos Islands, Peru and the Hawaiian Islands (Smith & Ferreira, 1977). Delete. Becomes a synonym of *Ischnochiton rugulatus* (Sowerby, 1832) [20] (Ferreira, 1983b).

14. ***Ischnochiton** rugulatus* (Sowerby, 1832). [20]. Genus changed from *Radsiella*. Synonyms: *Chiton catenulatus* Sowerby in Broderip & Sowerby, 1832; *Chiton petaloides* Gould, 1846 [19]; *Chiton mariposa* Dall, 1919; *Stenoplaz histrio* Berry, 1945. Delete as synonyms: *Chiton roseus* Sowerby, 1832 [not Blainville, 1825]; *C. pallidulus* Reeve, 1847; *Ischnochiton boogii* Haddon, 1886; *I. aethonus* Dall, 1919; *Stenoplax isoglypta* Berry, 1956. Lectotype: figs 11-12. Range: from Malarrimo Point, Baja California Sur, throughout the Gulf of California and south to Peru; Galapagos Islands; Socorro Island (Ferreira, 1983b). Ferreira (1985b) uses "*Radsiella rugulata* (Sowerby, 1832)" Thorpe in Keen, 1971 [not Chiton *rugulatus* Sowerby, 1832] as a synonym of *Stenoplax boogii* (Haddon, 1886). Kaas & Van Belle (1987) do not.

15. ***Ischnochiton skoglundi*** Ferreira, 1986. Length 4.8 mm. Playa Novillero, Nayarit, Mexico. Depth: 5 to 15 m. Known only from the type locality (Ferreira, 1986).

Ischnochiton species Thorpe, MS' [18]. Change genus (Smith, 1977).

16. ***Ischnochiton** tenuisculptus* (Carpenter, 1864). [21]. Change genus (Van Belle, 1983).

17. ***Ischnochiton** tridentatus* Pilsbry, 1893. [22]. Change genus (Smith, 1977).

18. ***Ischnochiton victoria*** Ferreira, 1987. Length 3.5 mm. Known only from Cocos Island, Costa Rica (Ferreira, 1987).

Genus *Stenoplax* (Carpenter MS) Dall, 1879
Subgenus *Stenoplax s.s.*

19. ***Stenoplax (S.) boogii*** (Haddon, 1886). Synonyms: *Chiton roseus* Sowerby in Broderip and Sowerby, 1832 [not Blainville, 1825]; *Ischnochiton bermudensis* Dall and Bartsch, 1911; *Ischnochiton (Stenoplax) aethonus* Dall, 1919; *Stenoplax isoglypta* Berry, 1956; "*Radsiella rugulata* (Sowerby, 1832)" Thorpe in Keen, 1971 [not *Chiton rugulatus* Sowerby, 1832]. Length 10 mm. Bahia de los Angeles, Gulf of California, Mexico, to Peru. Verified records from Cabo San Lucas, Baja California Sur, Mexico, to Bahia Herradura, Panama. Depth: 0 to 40 m (Ferreira, 1985b). *S. isoglypta* holotype figured (Hertz 1984). Add Cocos Island, Costa Rica to range (Ferreira, 1987). Add subgenus. Add synonym: *Ischnochiton dubium* Nowell-Usticke, 1969. Delete as synonym: "*Radsiella rugulata* (Sowerby, 1832)" Thorpe in Keen, 1971 [not *rugulatus* Sowerby, 1832]. Add Caribbean to range (Kaas & Van Belle, 1987).

20. ***Stenoplax (S.) circumsenta*** Berry, 1956. Length to 26 mm. Extend range into the Gulf of California from Isla Partida to Isla Espiritu Santo and Pichi-

linque, Baja California Sur, 1 to 15 m (Ferreira, 1972). Extend range to Mediol Island, 6 miles southwest of Guaymas, Sonora, Mexico (Hanselman, 1973). Ferreira (1983b) used *S. circumsenta* as a synonym of *Stenoplax (S.) corrugata*. Holotype figured (Hertz, 1984). Valid species. Length 20mm. Range: Scammon's Lagoon to Bahia Magdalena on the Pacific side of Baja California and on the Gulf side from Isla Monserrate to La Paz; near Guaymas, Sonora, on the Mexican mainland (Kaas & Van Belle, 1987).

21. ***Stenoplax (S.) corrugata*** (Carpenter in Pilsbry, 1892). Synonyms: *Ischnochiton biarcuatus* Dall, 1903; *Stenoplax circumsenta* Berry, 1956. Length 24 mm. Santa Cruz Island, California to Bahia Magdalena, Baja California Sur, Mexico. From Isla Danzante to Pichilinque on the western side of the Gulf of California and off Guaymas, Sonora, Mexico. Depth: 3 to 103 m (Ferreira, 1983b). Add subgenus. Delete *S. circumsenta* Berry, 1956 as a synonym. Limit range from Santa Cruz Island, California to Islas Guadalupe and San Martin, Baja California, and Clarion Island, Mexico (Kaas & Van Belle, 1987).

22. *Stenoplax (S.) limaciformis* (Sowerby, 1832). [24]. Add synonyms: *Chiton purpurascens* Adams, 1845; *Onitochiton* [sic] *pruinosum* Rochebrune, 1884 [not *Chiton prunosus* Gould, 1856]; "*Ischnochiton multicostatus* C.B. Adams," Dall, 1883 [not C.B. Adams, 1845]; *Ischnochiton (Stenoplax) floridanus* Pilsbry, 1892; *Chiton angustus* Clessin, 1904. Range: Isla Tiburon, Gulf of California, to Punta Ancon, Ecuador, and the Caribbean (Ferreira, 1985b). Delete as synonyms all above except *Chiton angustus* Clessin, 1904, and limit the range to the eastern Pacific (Bullock, 1985). Range: Gulf of California to Inner Lobos Island, Peru (Kaas & Van Belle, 1987).

Subgenus ***Stenoradsia*** Carpenter MS, Dall, 1879

Stenoplax (S.) conspicua (Carpenter MS, Pilsbry, 1892). Synonyms: *Maugerella conspicua* Carpenter MS; *Ischnochiton sarcosus* Dall, 1902; var *solida* (Carpenter in Pilsbry, 1892) (Kaas & Van Belle, 1980). Add subgenus. Delete. Range is north of the Panamic province (Kaas & Van Belle, 1987).

23. *Stenoplax (S.) magdalenensis* (Hinds, 1845). [25]. Add subgenus. Extend range on the western coast of Baja California from Bahia San Quintin to Cabo San Lucas and in the Gulf of California from Puerto Penasco, Sonora to Bahia Concepcion, Baja California Sur, Mexico, intertidal (Kaas & Van Belle, 1987).

24. *Stenoplax (S.) sonorana* (Berry, 1956). [23]. Holotype figured (Hertz, 1984). Add subgenus. *S. sonorana* becomes a full species. Length to 65mm. Range: northern half of the Gulf of California (Kaas & Van Belle, 1987).

Genus *Lepidozona* Pilsbry, 1892
Subgenus *Lepidozona s.s.*

25. ***Lepidozona (L.) allynsmithi*** Ferreira, 1974. [36]. Length 20 mm. Range: Los Candeleros and Isla Las Animas, Gulf of California, Mexico, to Bahia de Huevos, Costa Rica. Depth: 2 to 20 m (Ferreira, 1974). Add subgenus (Kaas & Van Belle, 1987).

26. ***Lepidozona (L.) clarionensis*** Ferreira, 1983. Length 15 mm. Endemic to Islas Revillagigedos, Mexico. Depth: 8 to 25 m (Ferreira, 1983b). Add subgenus (Kaas & Van Belle, 1987).

27. *Lepidozona (L.) clathrata* (Reeve, 1847). [31]. Add synonym: *Ischnochiton subclathratus* Pilsbry, 1892. Extend range south to Manzanillo, Colima, Mexico, and depth to 10 m (Ferreira, 1974). Add subgenus (Kaas & Van Beele, 1987).

28. *Lepidozona (L.) crockeri* (Willett in Hertlein & Strong, 1951). [32]. Extend range north to near Isla Monserrate, Gulf of California, Mexico (Ferreira, 1974). Add subgenus (Kaas & Van Belle, 1987).

Lepidozona elenensis (Sowerby, 1832). [33]. Change genus to *Callistochiton*. See number 38.

Lepidozona flavida (Thiele, 1910). [34]. Becomes a synonym of *Callistochiton elenesis*. See number 38.

29. ***Lepidozona (L.) formosa*** Ferreira, 1974. [35]. Length 25 mm. Isla San Francisco to Isla Cerralvo, Gulf of California, Mexico. Depth: 15 to 20 m (Ferreira, 1974). Add subgenus. Extend range northward to Isla Blanca (2 miles south of Puerto Escondido), Baja California Sur, Mexico (Kaas & Van Belle, 1987).

30. ***Lepidozona (L.) laurae*** Ferreira, 1985. Length 14.5 mm. Known only from the general locality of Guaymas, Sonora, Mexico, and at depths of 60 to 100 m (Ferreira, 1985a). Add subgenus (Kaas & Van Belle, 1987).

Lepidozona macleaniana Ferreira, 1985. Length 20 mm. Off Isla San Pedro Nolasco, Gulf of California, Mexico, depth 100-104 m. Known only from type locality (Ferreira, 1985a). Delete. Becomes a synonym of *L. rothi* Ferreira, 1983 (Kaas & Van Belle, 1987). See number 33.

31. ***Lepidozona (L.) pectinulata*** (Carpenter in Pilsbry, 1893). Synonyms: *Ischnochiton (Lepidopleurus) pectinatus* Carpenter, 1864 (nom. nud.); *Ischnochiton bryanti* Dall, 1919; *Ischnochiton brunneus* Dall, 1919; *Ischnochiton (Lepidozona) californiensis* Berry, 1931; *Ischnochiton clathratus* (Reeve, 1847). Length to 40 mm. Range: San Luis Obispo County, California to Bahia Magdalena, Baja California Sur, Mexico. Intertidal to about 20 m (Ferreira, 1978b).

32. ***Lepidozona (L.) retiporosa*** (Carpenter, 1864). Length 12 mm. Alaska to off the southern end of Baja California, Mexico, 137 to 453 m (Kues, 1974). Change genus from *Ischnochiton* (Smith, 1977). Synonyms: *Leptochiton punctatus* Whiteaves, 1887; *Ischnochiton venezius* Dall, 1919; *Ischnochiton (Ischnochiton) aureotinctus* Carpenter MS, in Pilsbry, 1892 (Ferreira 1978b). Add subgenus. Add synonym: ?*Ischnochiton subexpressus* Carpenter MS, Palmer, 1945 (nom. nud.)

(Kaas & Van Belle, 1987).

33. ***Lepidozona (L.) rothi*** Ferreira, 1983. Up to 15 mm long. Known only from Clarion Island, Mexico, and Cocos Island, Costa Rica. Depth: 55 to 110 m (Ferreira, 1983b). Add synonym: *Lepidozona macleaniana* Ferreira, 1985. Add Isla San Pedro Nolasco, Gulf of California, to range (Kaas & Van Belle, 1987).

34. *Lepidozona (L.) serrata* (Carpenter, 1864). [37]. Extend range north to Monterey Bay, California, and south to Mazatlan, Sinaloa, Mexico, and depth to 10 m (Ferreira, 1974). Add subgenus (Kaas & Van Belle, 1987).

35. ***Lepidozona (L.) stohleri*** Ferreira, 1985. Length 26 mm. Known only from Isla Angel de la Guarda and Isla Danzante, Gulf of California, and Bahia de los Angeles, Baja California, Mexico. Depth: 12 to 60 m (Ferreira, 1985a). Add subgenus (Kaas & Van Belle, 1987).

36. *Lepidozona (L.) subtilis* Berry, 1956. [38]. Distribution confined to northern half of the Gulf of California, Mexico (Ferreira, 1984). Holotypes of *L. subtilis* and synonym *L. pella* Berry, 1963, figured (Hertz, 1984). Add subgenus (Kaas & Van Belle, 1987).

Subfamily CALLISTOPLACINAE Pilsbry, 1893
Genus *Callistochiton* (Carpenter MS) Dall, 1879

Callistochiton carmenae A.G. Smith & Ferreira, 1977. Synonym: *Callistochiton shuttleworthianus* Pilsbry, 1893. Length 8.7 mm. Known only from the Galapagos Islands (A. G. Smith & Ferreira, 1977). Delete. Becomes a synonym of *Callistochiton pulchellus* (Gray, 1828) (Ferreira, 1979). See number 41.

37. *Callistochiton colimensis* (A.G. Smith, 1961). [26]. Add synonym: *Ischnochiton lowei* Pilsbry in Pilsbry & Lowe, 1932. Extend range south to Panama and depth to 340 m (Ferreira, 1979a).

Callistochiton duncanus Dall, 1919. [27]. Change genus to *Chaetopleura*. See number 44.

38. **Callistochiton** *elenensis* (Sowerby, 1832). [33] Change genus. Add synonyms: *Callistochiton flavidus* Thiele, 1910; *Lepidozona flavida* (Thiele) Thorpe in Keen, 1971. Remove as synonym *Lepidopleurus clathratus* Carpenter, 1857 [not Reeve, 1847]. Extend range south to Punta Ancon, Ecuador, and depth to 90 m (Ferreira, 1979a).

39. *Callistochiton gabbi* Pilsbry, 1893. [28]. Add synonyms: *Callistochiton infortunatus* Pilsbry, 1893; *Callistochiton decoratus infortunatus* Dall, 1921; *Callistochiton leidensis* Nierstrasz, 1905. Range: throughout the Gulf of California, Mexico, to Ecuador. Depth: to 40 fathoms (Ferreira, 1979a).

Callistochiton infortunatus Pilsbry, 1893. [29]. Becomes a synonym of *C. gabbi*. See number 39.

40. ***Callistochiton periconis*** Dall, 1908. [30]. Add synonyms: *Callistochiton fisheri* Dall, 1919; "*Chiton pulchellus* Gray" of authors not Gray, 1828. Remove *Chiton bicostatus* Orbigny, 1841, as synonym. Length 15 mm. Near San Juan del Sur, Nicaragua, to Punta Cruces, Colombia. Intertidal to 30 m (Ferreira, 1979a).

41. ***Callistochiton pulchellus*** (Gry, 1828). Synonyms: *Chiton bicostatus* Orbigny, 1841; *Callistochiton carmenae* A.G. Smith & Ferreira, 1977; *Callistochiton shuttleworthianus* Pilsbry in Bergenhayn, 1936. Length 8.7 mm. Galapagos Islands, Ecuador, and Chile. Known only intertidally (Ferreira, 1979a).

Genus *Callistoplax* (Carpenter MS) Dall, 1882

42. *Callistoplax retusa* (Sowerby, 1832). [43]. Van Belle (1983) makes *Callistoplax* a subgenus of *Callistochiton*. D. Eernisse (pers. comm., 1989) says that current thinking returns *Callistoplax* to genus status.

Genus *Ceratozona* Dall, 1882

43. *Ceratozona* ***squalida*** (Adams, 1845). [46]. Synonyms: *Chiton rugosus* Sowerby, 1840 [not Gray, 1826]; *Chiton guildingii* Reeve, 1847; "Ch. bicolor, Adams" Gray, 1847; *Ceratozona angusta* Thiele, 1909. Nicaragua to Costa Rica; Florida to Barbados, West Indies. Depth: 0 to 1 m (Ferreira, 1985b).

Subfamily CHAETOPLEURINAE Plate, 1899
Genus *Chaetopleura* Shuttleworth, 1853.

44. *?Chaetopleura duncanus* (Dall, 1919). [27]. Change genus to *Calloplax*. Length 13 mm (Smith & Ferreira, 1977). Genus *Calloplax* moved to family Callistoplacidae (Ferreira, 1978c). Return *Calloplax* to family Chaetopleuridae (Ferreira, 1982a). *Calloplax* treated as a subgenus of *Callistochiton* in the subfamily Callistoplacinae (Van Belle, 1983). *Calloplax* becomes a synonym of *Chaetopleura* (Lyons, 1985). *Chaetopleura duncanus* not included in the review of the genus *Chaetopleura* by Kaas and Van Belle (1987); hence the question on the correct generic placement.

Subgenus *Chaetopleura s.s.*

45. ***Chaetopleura (C.) benaventei*** Plate, 1899. Synonym: *Variolepis iquiquensis* Plate, 1899. Length to 24 mm. Range: northern Peru to central Chile, 8 to 20 m (Kaas & Van Belle, 1987).

46. ***Chaetopleura (C.) hanselmani*** (Ferreira, 1982). Length 9 mm. Range: Mazatlan, Sinaloa, Mexico, to Peru and the Galapagos Islands. Intertidal to 17 m. Described as genus *Calloplax* and returned to the Chaetopleuridae (Ferreira, 1982a). *Calloplax* becomes a subgenus of *Callistochiton* (Van Belle, 1983). *Calloplax* becomes a synonym of genus *Chaetopleura* (Lyons, 1985). Add subgenus. Synonym: *Chaetopleura cf. C. mixta* (Dall, 1919) Smith & Ferreira, 1977 (Kaas & Van Belle, 1987).

47. *Chaetopleura (C.) lurida* (Sowerby, 1832). [41]. Synonyms: "*Chaetopleura lurida* (Sowerby)" *ex auttore* treating Panamic species including Thorpe in Keen, 1971 [not *Chiton luridus* Sowerby (1st) in Broderip & Sowerby, 1832]; "*Chiton columbiensis* Sowerby, 1832" Thorpe in Keen, 1971 [not *Chiton*

catenulatus Sowerby, 1832]; "*Chiton jaspideus* Gould, 1846," Thorpe in Keen, 1971 [not *Chiton jaspideus* Gould, 1846]; *Lepidopleurus bullatus* Carpenter, 1857; *Lepidopleurus bullatus calciferus* Carpenter, 1857; *Ischnochiton parallelus* Carpenter, 1864; *Ischnochiton prasinatus* Carpenter, 1964; *Choetopleura* [sic] *dacrydigera* Rochebrune, 1882. Occurs from the central part of the Gulf of California, Mexico, to Isla Gorgona, Colombia (Ferreira, 1983a). Remove *C. lurida* as a synonym. Add synonyms: *C. scabriculus* Sowerby in Broderip & Sowerby, 1832; *Chiton sowerbyanus* Clessin, 1904; *Chaetopleura scabriscula*; Ferreira, 1983; *?Chiton dieffenbachii* Reeve, 1847. Intertidal to 30 m (Kaas & Van Belle, 1987).

48. ***Chaetopleura (C.) peruviana*** (Lamarck 1819). Synonyms: *Chiton hirsutus* Deshayes MS?, Gray, 1828; *Chaetopleura peruviana var. australis* Plate, 1899. Length to 50 mm. Range: Cape San Lorenzo, Ecuador, south to Chonos Archipelago, Chile, intertidal to 40 m (Kaas & Van Belle, 1987).

49. ***Chaetopleura (C.) roddai*** Ferreira, 1983. [39]. Length to 33 mm. Range: Fort Kobbe, Panama, to Bocapan, Tumbes Province, Peru, intertidal to 90 m (Ferreira, 1983a). Add subgenus. Correct Spelling from *roddae* (Kaas & Van Belle, 1987).

50. ***Chaetopleura (C.) shyana*** Ferreira, 1983. Length 27 mm. Isla Pata, Bahia de los Angeles, Baja California; Isla Turner, and Isla Partida, Mexico. Intertidal to shallow subtidal zone (Ferreira, 1983a). Add subgenus (Kaas & Van Belle, 1987).

51. *Chaetopleura (C.)* ***unilineata*** Leloup, 1954. [42]. Synonym: "*Chaetopleura mixta* (Dall, 1919)" *ex auttore* treating Panamic species including Thorpe in Keen, 1971 [not *Tonicia mixta* Dall, 1919]. Length to 32 mm. From the head of the Gulf of California to northern Peru, intertidal to 90 m (Ferreira, 1983a). Add subgenus (Kaas & Van Belle, 1987).

Subgenus ***Pallochiton*** Dall, 1879

52. ***Chaetopleura (P.) lanuginosa*** (Carpenter MS, Dall, 1879). Synonyms: *Arthuria filosa* Carpenter in Dall, 1882 (nom. nud.); *Nuttallina magdalena* Dall, 1919; *Tonicia mixta* Dall,1919 [pars] [not *Chaetopleura mixta* (Dall) of authors treating Panamic species; *Chaetopleura raripustulosa* Pilsbry in Pilsbry & Lowe, 1932; *Chaetopleura (Pallochiton) eurplax* Berry, 1945. Length to 60 mm. Outer Baja California from Ensenada to Bahia Magdalena; San Felipe to Bahia Concepcion on the western side of the Gulf of California, and Bahia de Adair to Topolobampo, Sinaloa, on the mainland side. Mostly intertidal but extends to 91 m (Ferreira, 1983a). Length to 40 mm. Remove as synonyms: *Tonicia mixta* Dall, 1919; *Chaetopleura raripustulosa* Pilsbry in Pilsbry & Lowe, 1932; *Chaetopleura euryplax* Berry, 1945. Limit range to the west coast of Baja California from Bahia Todos Santos, Baja California to Bahia Magdalena, Baja California Sur, Mexico (Kaas & Van Belle, 1987).

53. ***Chaetopleura (P.) lanuginosa mixta*** (Dall, 1919). [40]. Synonyms: *Tonicia mixta* Dall, 1919; *Chaetopleura raripustulosa* Pilsbry in Pilsbry & Lowe, 1932 (nom. nud.); *Chaetopleura (Pallochiton) euryplax* Berry, 1945. Range the upper Gulf of California, south to Bahia Concepcion on the Baja California side, and south to Bahia Topolobampo, Sinaloa on the Mexican mainland (Kaas & Van Belle, 1987).

Subfamily LEPIDOCHITONINAE Iredale, 1914
Genus *Lepidochitona* Gray, 1821

54. ***Lepidochitona beanii*** (Carpenter, 1857). [44]. Change genus from *Mopaliella*. Add synonyms; *Chiton bipunctatus* Sowerby (1st) in Broderip & Sowerby, 1832; *Tonicella (Mopaliella) stigmata* Dall, 1909. Extend range south to Peru (Ferreira, 1982b) and the Caribbean (Ferreira, 1985b). Not Caribbean (Kaas & Van Belle, 1985b).

55. ***Lepidochitona keepiana*** Berry, 1948. Synonyms: "*Lepidochitona dentiens* (Gould)" Berry, 1922 [not *Lepidochitona dentiens* (Gould, 1846)]; *Ischnochiton (Trachydermon) dentiens* (Gould) Pilsbry, 1892. Length to 16 mm. Range: Monterey, California, to Rancho Socorro, Baja California; Isla Socorro, Mexico. Depth: intertidal to 10 m (Ferreira, 1983b). Holotype figured (Hertz, 1984).

Subgenus *Dendrochiton* Berry, 1911

Lepidochitona (D.) laurae (Berry, 1963). [47]. *Dendrochiton* becomes subgenus (Van Belle, 1983). Holotype figured (Hertz, 1984). Delete. Becomes synonym of *L. lirulata*. See number 56.

56. *Lepidochitona (D.) lirulata* (Berry, 1963). [48]. *Dendrochiton* becomes subgenus (Van Belle, 1983). Add synonym: *Dendrochiton laurae* Berry, 1963. Range: northern Gulf of California to Bahia de los Angeles in Baja California and Guaymas, Sonora, on the mainland of Mexico. All intertidal (Ferreira, 1982b). Holotype figured (Hertz, 1984).

Genus *Nuttallina* (Carpenter MS) Dall, 1871

57. ***Nuttallina californica*** (Nuttall MS, Reeve, 1847). Synonyms: *Chiton scaber* Reeve, 1847 [not Blainville, 1825];*Acanthopleura scabra* (Reeve) Carpenter, 1864;*Acanthopleura fluxa* Carpenter, 1864 [nom. nud.]. Length to 53 mm. Range: Sonoma County, California to Bahia Magdalena, Baja California Sur, Mexico, in the upper and middle intertidal zone (Ferreira, 1982b). Delete *Acanthopleura scabra* (Reeve) Carpenter, 1864, as a synonym (Kaas & Van Belle, 1985b).

58. *Nuttallina crossata* Berry, 1956. [45]. Add synonym *Nuttallina mexicana* Pilsbry in Pilsbry & Lowe, 1932 (nom. nud.). Extend range southward to Puerto Ballandra, Baja California Sur, Mexico (Ferreira, 1982b). Holotype figured (Hertz, 1984).

Family MOPALIIDAE Dall, 1889
Subfamily MOPALIINAE Dall, 1889
Genus *Placiphorella* (Carpenter MS) Dall, 1879

59. *Placiphorella blainvillii* (Broderip, 1832). [49]. Extend range north to Cocos Island, Costa Rica,

and depth to 120 m. Presence in deep water off the Galapagos Islands not reconfirmed since first published (Smith & Ferreira, 1977).

60. ***Placiphorella pacifica*** Berry, 1919. Synonym: *Placiphorella ushakovi* Yakovleva, 1952. Length to 33 mm. Range: Okhostsk Sea, Pacific Northwest, and off Guaymas, Sonora, Mexico. Depth: 366 to 878 m (Smith, 1974).
61. *Placiphorella velata* (Carpenter MS) Dall, 1879. [50].

Family CHITONIDAE Rafinesque, 1815
Subfamily CHITONINAE Rafinesque, 1815
Genus *Chiton* Linnaeus, 1758
Subgenus *Chiton s.s.*

62. *Chiton (C.) stokesii* Broderip, 1832. [5]. Add synonyms: *Chiton interruptus* (Carpenter MS) Pilsbry, 1893 [nom. nud.]; *Chiton stokesi broderipi* Clessin, 1903; *Chiton latus* Boone, 1933 [not Sowerby, 1825] (Kaas & Van Belle, 1980). Add Cocos Island, Costa Rica, to range (Ferreira, 1987). Range: Guatemala to Ecuador. Not found in Mexico (Bullock, 1988).
63. *Chiton (C.) sulcatus* Wood, 1815. [6]. Add synonym *Chiton woodii* Clessin, 1903 (Kaas & Van Belle, 1980). Add subgenus (Bullock, 1988).
64. *Chiton (C.) virgulatus* Sowerby, 1840. [7]. Add synonym *?Chiton (Radsia) caerulescens* Shuttleworth, 1853 [nom. nud.] (Kaas & Van Belle, 1980). Add subgenus. Add Bahia Magdalena, Baja California Sur, to range (Bullock, 1988).

Subgenus ***Amaurochiton*** Thiele, 1893

65. ***Chiton (A.) cumingsii*** Frembly, 1827. Add subgenus. Length 45 mm. Range: Tumbes, Peru, to Calbuco, Chile, intertidal (Bullock, 1988).

Subgenus ***Diochiton*** Thiele, 1893

66. *Chiton* ***(D.)*** *albolineatus* Broderip & Sowerby, 1829. [2]. Add subgenus. Extend range northward to Guaymas, Sonora, Mexico, and southward to Guatemala (Bullock, 1988).
67. *Chiton* ***(D.)*** *articulatus* Sowerby, 1832. [3]. Range: Mazatlan, Sinaloa, to Puerto Angel, Oaxaca, Mexico (Ferreira, 1983b). Add subgenus. Synonym: *Chiton similis* [Gray MS]. Range: Mazatlan to Puerto Guatulco, Oaxaca, Mexico (Bullock, 1988).
68. *Chiton* ***(D.)*** *goodallii* Broderip, 1832. [4]. Intertidal (Smith & Ferreira, 1977). Add synonym: *Chiton (Radsia) chierchiae* Nierstrasz, 1906 (Kaas & Van Belle, 1980). Not found at Cocos Island (Ferreira, 1987). Add subgenus (Bullock, 1988).

Subgenus ***Chondroplax*** Thiele, 1893

69. ***Chiton (C.) granosus*** Frembly, 1827. Add subgenus. Length to 75 mm. Range: Tumbes, Peru to Isla de Chiloe, Chile, intertidal (Bullock, 1988).

Subfamily TONICIINAE Pilsbry, 1893
Genus *Tonicia* Gray, 1847

70. *Tonicia forbesii* Carpenter, 1857. [9].
71. *Tonicia* ***forbesii*** *arnheimi* Dall, 1903. [8]. *T. arnheimi* becomes a subspecies. Low intertidal to deeper water. Figured (Smith & Ferreira, 1977).

Suborder ACANTHOCHITONIA Bergenhayn, 1930
Family ACANTHOCHITONIDAE Pilsbry, 1893
Subfamily ACANTHOCHITONINAE Pilsbry, 1893
Genus *Acanthochitona* Gray, 1821

72. ***Acanthochitona angelica*** Dall, 1919. Holotype fig. 4. Synonym: *A. jacquelinae* A.G. Smith & Ferreira, 1977. Range: Bahia de los Angeles, Baja California and Islas Tres Marias, Mexico; Isla Santa Cruz, Galapagos Islands, Ecuador, 40 to 50 m (Watters, 1981).
73. *Acanthochitona arragonites* (Carpenter, 1857). [10]. Extend range to Salinas, Ecuador. Recognized by "D"-shaped pustules. All other Panamic province *Acanthochitona* have tear-drop-shaped or oval pustules. *A. andersoni* Watters, 1981 is a cognate species from the western Pacific (Watters, 1981).
74. *Acanthochitona avicula* (Carpenter, 1864). [11]. Possible new species from Galapagos Islands, Ecuador reported as "*CF avicula*" (Smith & Ferreira, 1977). Remove *?A. angelica* Dall, 1919 as a synonym. Lectotype designated for *A. avicula var. diegoensis* (Pilsbry, 1893). Delete "*CF avicula*" (Smith & Ferreira, 1977) (Watters, 1981).
75. *Acanthochitona exquisita* (Pilsbry, 1893). [12].
76. *Acanthochitona ferreirai* Lyons, 1988. [14]. Synonym: *Acanthochitona rhodea* Thorpe in Keen, 1971 [pars] [not *A. rhodea* (Pilsbry, 1893)]. Length 28.2 mm. Range: Costa Rica and Panama, intertidal and subtidal (Lyons, 1988).
77. *Acanthochitona hirudiniformis* (Sowerby, 1832). [13]. Add synonym: *A. panamensis* Pilsbry, 1932 (Kaas & Van Belle, 1980). Add Galapagos Islands, Ecuador, to range (Smith & Ferreira, 1977). Watters (1981) uses *A. hirudiniformis hirudiniformis* (Sowerby, 1832) with synonyms *A. coquimboensis* (Leloup, 1941) and *A. tabogensis* A.G. Smith, 1961. *A. hirudiniformis peruviana* (Leloup, 1941) is considered to be a separate subspecies (Watters, 1981).
78. ***Acanthochitona imperatrix*** Watters, 1981. Synonyms: *Acanthochitona species?* A.G. Smith & Ferreira, 1977; *A. galapagana* (Pilsbry MS). Length 8.9 mm. Range: southern California to the Galapagos Islands. Depth: 14.6 to 17.4 m (Watters, 1981).

Acanthochitona jacquelinae A.G. Smith & Ferreira, 1971. Length 10 mm. Isla Santa Cruz, Galapagos Islands, Ecuador, 40 to 50 m (Smith & Ferreira, 1977). Delete. Becomes a synonym of *A. angelica* Dall (Watters, 1981). See number 72.

Acanthochitona rhodea (Pilsbry, 1893). [14]. Add synonym: *Acanthochites (Notoplax) hemphilli* Pilsbry, 1893. Extend range north to Guaymas, Sonora, Mexico, and the Caribbean (Ferreira, 1985b). *A. rhodea* becomes a synonym of *A. hem-*

philli (Pilsbry) (Watters, 1981). Delete as a Panamic province species. Both *A. rhodea* and *A. hemphilli* are confined to the Caribbean coasts of Costa Rica, Panama, and Colombia (Lyons, 1988).

79. ***Acanthochitona shaskyi*** Ferreira, 1987. Length 6 mm. Chatham Bay, Cocos Island, Costa Rica, in 46 to 69 m. Known only from the type lot (Ferreira, 1987).

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1988. The genus *Chiton* in the new world (Polyplacophora: Chitonidae). Veliger 31(3/4):141-191, 144 text figs. (Oct. 3).

Ferreira, Antonio J.

1972. *Stenoplax circumsenta* Berry, 1956, in the Gulf of California. Veliger 15(1):55-56, 2 text figs. (Jul. 1).

1974. The genus *Lepidozona* in the Panamic province, with the description of two new species. Veliger 17(2):162-180, 24 text figs. (Oct. 1).

1978a. A new species of chiton (Neoloricata: Ischnochitonidae) from the Galapagos Islands. Bull. So. Cal. Acad. Sci. 77(1):36-39, 2 text figs. (May 8).

1978b. The genus *Lepidozona* (Mollusca: Polyplacophora) in the temperate eastern Pacific, Baja California to Alaska, with the description of a new species. Veliger 21(1):19-44, 33 text figs. (Jul. 1).

1978c. The genus *Calloplax* Thiele, 1909 (Mollusca: Polyplacophora) in the Americas. Bull. So. Cal. Acad. Sci. 77(2):56-64, 5 text figs. (Aug.)

1979a. The genus *Callistochiton* Dall, 1879 (Mollusca: Polyplacophora in the eastern Pacific, with the description of a new species. Veliger 21(4):444-466, 27 text figs. (Apr. 1).

1979b. The family Lepidopleuridae (Mollusca: Polyplacophora) in the eastern Pacific. Veliger 22(2):145-165, 40 text figs. (Oct. 1).

1980. A new species of *Lepidopleurus* Risso, 1826 (Mollusca: Polyplacophora) in the deep waters of the eastern Pacific. Veliger 23(1):55-61, 10 text figs. (Jul. 1).

1982a. A new species of *Calloplax* (Mollusca: Polyplacophora) in the eastern Pacific. Veliger 24(4):321-324, 8 text figs. (Apr. 1).

1982b. The family Lepidochitonidae Iredale, 1914 (Mollusca: Polyplacophora) in the northeastern Pacific. Veliger 25(2):93-138, 8 pls.; 40 text figs. (Oct. 1).

1983a. The genus *Chaetopleura* Shuttleworth, 1853 (Mollusca; Polyplacophora) in the warm-temperate and tropical eastern Pacific, southern California to Peru, with the description of two new species. Veliger 25(3):203-224, 35 text figs. (Jan. 1).

1983b. The chiton fauna of the Revillagigedo Archipelago, Mexico. Veliger 25(4):307-322, 10 text figs. (Apr. 1).

1984. A new species of *Ischnochiton* (Mollusca; Polyplacophora) in the Gulf of California. Veliger 26(3):179-182, 6 text figs. (Jan. 3).

1985a. Three new species of *Lepidozona* (Mollusca; Polyplacophora) from the Gulf of California. Veliger 27(4):423-429, 14 text figs. (Apr. 1).

1985b. Chiton (Mollusca; Polyplacophora) fauna of Barbados, West Indies, with the description of a new species. Bull. Mar. Sci. 36(1):189-219, 18 text figs.

1986. A new species of *Ischnochiton* (Mollusca: Polyplacophora) from the tropical eastern Pacific. Veliger 28(4):448-452, 5 text figs. (Apr. 1).

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Hanselman, George A.

1973. *Stenoplax circumsenta* Berry, 1956: a range extension. Of Sea and Shore, Spring 1973, pp. 20-21, 33.

1977. New range extensions for chitons (Amphineura: Polyplacophora). Veliger 20 (1):62 (Jul. 1).

Hertz, Carole M.

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Kues, Barry S.

1974. New occurrences of *Ischnochiton retiporosus* Carpenter, 1864 in the eastern Pacific Ocean. Veliger 16(4):366 (Apr. 1).

Lyons, William G.

1985. *Chaetopleura staphylophera* (Polyplacophora: Chaetopleuridae), a new species for the southwestern United States and Bahamas. Nautilus 99(2-3):35-44, 30 text figs. (Apr. 29).

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Smith, Allyn G.

1974. The deep-water chiton *Placiphorella pacifica* Berry. Veliger 17(2):159-161, 4 text figs. (Oct. 1).

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Van Belle, Richard A.

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Minutes
Board Meeting
Western Society of Malacologists
Los Angeles, California
25 June 1989

The meeting was called to order by President H. Bertsch at 2:08 p.m.

Present: Roland Anderson, Hans Bertsch, Henry Chaney, Eugene Coan, Bert Draper, Bill Emerson, Terrence Gosliner, Carole Hertz, Kirstie Kaiser, LouElla Saul, and Paul Scott.

Bill Emerson reported on the San Diego Natural History Museum situation and stated that the Attorney General closed the case because the SDNHM has fulfilled the legal requirements of the Joshua L. Bailey bequest. Even though they have not fulfilled the intent of the bequest, it would take legal action to pursue the matter. It was suggested that the new Chairman of the Board of SDNHM be asked to reconsider the matter and that the museum be reminded of the intent to pursue molluscan studies.

Secretary's Report: The 1988 secretary's report was approved as summarized by K. Kaiser.

Treasurer's Report: H. Chaney reported on the dues increase scheduled for 1990. Costs are exceeding our income for the Annual Report and the opinion is that the 1990 membership dues should be raised. After some discussion it was moved that the question of raising dues be brought to the general membership and that the dues be raised as follows:

General membership	$15.00
Student membership	6.00
Family member	2.00

Student Grant: E. Coan gave a brief history of the WSM Student Grant. H. Chaney reported making available to V. Kenk a $1,000 grant in February 1989.

After considerable discussion on the grant amount it was suggested that the formal policy of $1,000 every two years remain the same, and should there be an excess in the fund, that we offer a special student grant on the alternate year.

Dr. Gosliner suggested that we offer a special grant for the year 1990 as extra funds are available at this time; MSP; the amount will be determined following the 1989 AMU-WSM meeting.

MSP that every other year the amount of $1,000 be available for the student grant and that if funds are available we offer a special grant on the alternate year with the amount to be determined at the time of the offering.

President Bertsch will advise the general membership on 6/29/89 concerning the student grants.

After considerable discussion about various shell clubs having the option of combining money or distributing scholarship notices, in order to maximize time and effort, H. Bertsch suggested that P. Scott collaborate with the Student Grant Committee in working out a viable program with the various shell clubs on the possiblility of offering joint grants.

E. Coan reported Susan McBride as the winner of this year's Student Grant Award. She is a student of J. Nybakken and was commended for her work on the Haliotidae.

WSM 1990 Meeting: R. Anderson reported that the plans for the 1990 meeting of WSM to be held on the University of Washington campus in Seattle are progressing well. The dates will be June 18-22. One symposium will be on Alaskan mollusks and chaired by Paul Scott. Roland cautioned that the Goodwill Games will be in Seattle at that time so early reservations are suggested.

WSM 1991 Meeting: P. Scott reported that the University of California at Berkeley will be the site of the 1991 WSM. Because the AMU will be meeting in the west it was recommended that we have a joint meeting.

MSP. The WSM will have a joint meeting with the AMU in 1991. P. Scott will advise the general membership on 6/26/89.

Nominating Committee: Slate of officers for 1990 are as follows:

President	Roland Anderson
First VP	Paul Scott
Second VP	LouElla Saul
Secretary	Cliff Coney
Treasurer	Henry Chaney

President Bertsch will appoint a new Auditing Committee and Student Best Paper Committee.

H. Chaney informed the Nominating Committee that a new candidate for Historian would be needed for 1991.

President Bertsch will ask the present Student Grant Committee and Historian to continue for 1990.

The first president of the WSM, Dave Mulliner, paid a visit to the board meeting to take some candid photos and was welcomed by Hans.

C. Hertz questioned the fact that there was no membership roster in the Annual Report. After explanation from the editor and some discussion it was **MSP** that a membership roster will be included in the Annual Report.

President Bertsch commended Secretary Kaiser for her three years as Secretary of the WSM.

There being no further business, the meeting was adjourned at 3:30 p.m.

Respectfully submitted by Kirstie L. Kaiser, Secretary, and approved by Hans Bertsch, President.

Minutes of the 1989 Business Meeting of the Western Society of Malacologists

The 1989 Business Meeting of the Western Society of Malacologists was called to order at 5:00 PM 29 June 1989 by President Hans Bertsch. A motion that the Secretary's report be accepted as published was proposed and seconded and the vote to approve the motion was unanimous.

WSM Treasurer Chaney reported income for 1989 at the time of the meeting was $1,677.00 including dues income of $1,233.00, and student grant contributions of $444.00. Current expenditures for 1989 included $1,709.00 for the Annual Report and $203.00 for the reprinting of Occasional Paper #1. He reported that the net worth of the WSM was $6,075.00, and that this figure would be significantly augmented by the end of the accounting period. Income from the 1989 joint meeting with AMU (not included in the above net worth) totaled $3,964.00 with the shell auction bringing in $3,791.00 and reprint sales of $173.00.

Chaney introduced the topic of WSM membership dues. In the past couple of years income from dues has not covered the production of the Annual Report. The deficit is about $3.00 per member/per copy. He requested that regular annual membership dues be raised from $10.00 to $15.00, student dues to be raised from $4.00 to $6.00, and additional family memberships to remain at $2.00. Tom Burch moved that the proposed dues increase be approved as presented, the motion was seconded by Terrence Gosliner, and the vote to approve the motion was unanimous.

The student grant committee reported that a WSM grant of $1,000.00 will be awarded to Susan McBride of Moss Landing Marine Laboratory for her research on molluscan larval characteristics and settlement rates.

President Bertsch proposed a special student grant for 1990 of $1,000.00. During discussion, Dr. Shasky wanted funds earmarked in future WSM endowments to support symposium participants. Lindsey Groves recommended splitting the $1,000.00 sum into two grants of $500.00 each. Dr. Gosliner noted that modern costs of research (e.g. SEM, molecular analyses, etc.) warrants a single grant award of $1,000.00. Dr. Gosliner further suggested that future awards be awarded as WSM funds permit and recommended that universities, institutions, and the business sector contribute toward future WSM student grants. Beatrice Burch noted that the HMS has awarded as many as six student grants annually ranging from $250.00 to $2,000.00 with the grant recipient becoming responsible for a future HMS Newsletter article. Tom Burch moved that the 1990 student grant of $1,000.00 be approved as presented by Bertsch; the motion was seconded and the vote to approve the motion was unanimous.

Paul Scott reported on the WSM meeting in 1991 at Berkeley as a joint meeting with AMU during which he will be WSM president, and Dr. Carole Hickman will be AMU president. Scott announced a proposed symposium on Northeastern Pacific Mollusca, and a workshop on the anatomy and physiology of Bivalvia to be held at Moss Landing Marine Laboratory.

Roland Anderson reported on progress of the upcoming 1990 WSM meeting to be held on the campus of the University of Washington at Seattle. A proposed symposium on Alaskan Molluscs is to be organized by Paul Scott and Nora Foster. Intertidal field trips are planned for Friday and Saturday of that week.

Bertsch reported that the WSM Annual Report will be larger due to the inclusion of 1989 AMU/WSM meeting abstracts.

Carole Hertz of the nominating committee read the slate of WSM officers for 1990, it was MSP to accept them as presented:

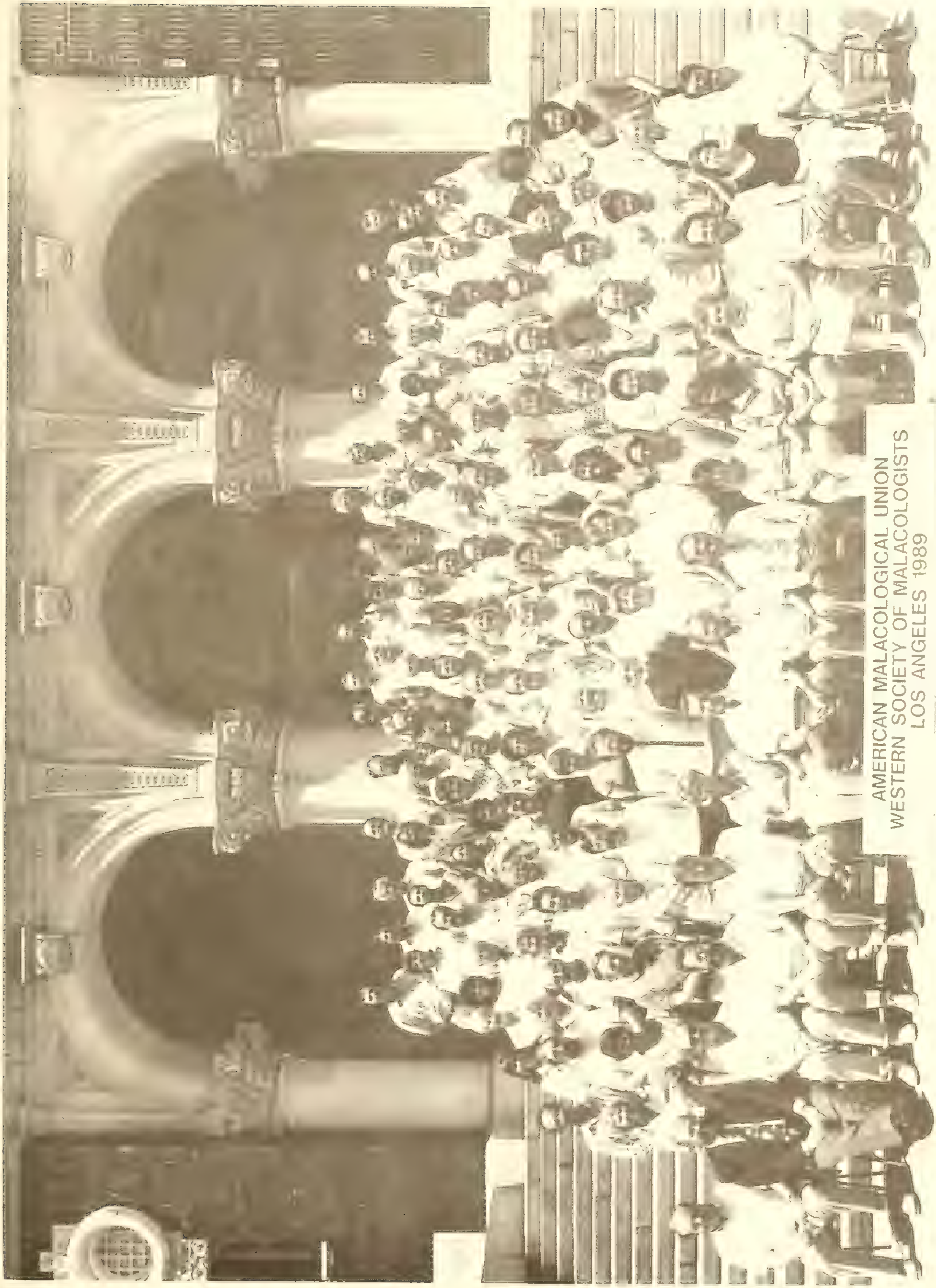
President .... Roland Anderson
1st Vice President .... Paul Scott
2nd Vice President......... LouElla Saul
Treasurer................ Henry Chaney
Secretary .... Clif Coney
Members at Large ..... James Nybakken
Lindsey T. Groves

Gosliner presented a motion to thank all those responsible for organizing the AMU/WSM joint meeting, reprint sales and auctions. MSP.

Gosliner and Paula Mikkelsen of the Committee for Student Paper Awards announced that the best student paper was by Leslie Newman of the University of Queensland, Australia for her work on the biology and distribution of atlantid heteropod molluscs from the Great Barrier Reef, Australia. Newman will receive a cash award of $100.00.

With no further business the 1989 WSM Business Meeting was adjourned.

Respectfully submitted by C. Clifton Coney, Secretary Elect, acting in behalf of Secretary Kirstie Kaiser.


AMERICAN MALACOLOGICAL UNION
WESTERN SOCIETY OF MALACOLOGISTS
LOS ANGELES 1989

Announcements of Future Meetings

The 23rd Annual Meeting of the W.S.M. will be held 18-22 June 1990, in Seattle, Washington, on the campus of the University of Washington. Three days are available for scheduled papers and symposia, including a major symposium on all aspects of mollusca; two evenings are also available for slide shows. A collecting field trip will be on Friday, 22 June, taking advantage of the lowest tides of the year.

For further information, please contact W.S.M. President Roland Anderson at The Seattle Aquarium, Pier 59, Seattle, Washington 98101 (Telephone: 206-386-4359).

The 24th annual meeting of the Western Society of Malacologists and the 57th annual meeting of the American Malacological Union will be a combined meeting held in Berkeley, California, 23-29 June 1991.

The meeting site will be on the campus of the University of California, Berkeley. Lodging will be provided on campus as well as in adjacent hotels.

Two major symposia are planned: "Evolutionary History of the Molluscan Fauna of the North Pacific" and "Molluscan Origins and the Environmental Setting of Early Molluscan Evolution." In addition there will be a workshop on marine bivalve molluscs following the meeting. Field trips to nearby marine laboratories and marine sanctuaries are under consideration.

For further information contact: Paul Scott, Santa Barbara Museum of Natural History, 2559 Puesta del Sol, Santa Barbara, CA 93105, (805) 682-4711, or Carole Hickman, Department of Integrative Biology, University of California, Berkeley, CA 94720. Telephone (415) 642-1821.

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1988 - 30 September 1989

INCOME

Membership dues	$1,729.00	
Student grant donations (1989)	444.00	
Publication sales and page charges	140.00	
Interest on savings accounts	311.75	
Reimbursement from 1989 joint meeting advance	532.00	
Auction and reprint sales	3,964.40	
TOTAL INCOME during period		**$7,121.15**

EXPENSES

Annual report	$1,709.98	
Memberships and fees	37.00	
Reimbursements to officers	283.66	
Reprinted publication (Occasional Paper #1)	203.52	
Student grant	1,000.00	
Best student paper	100.00	
TOTAL EXPENSES during period		**$3,334.16**
Net Gain for period		3,786.99
Beginning balance (1 October 1988)		5,996.55
NET WORTH on October 1989		**$9,783.54**

Regular Individual Memberships

ABBOTT, Edith, 1264 West Cienega Ave., San Dimas, CA 91773
ABBOTT, Dr. R. Tucker, P.O. Box 2255, Melbourne, FL 32902-2255
ADAMS, Catherine R., 13346 Birchwood Dr., Sunnymead, CA 92388
ALLMON, Dr. Warren D., Dept. of Geology, University of South Florida, Tampa, FL 33620
ANDERSON, Roland C., Seattle Aquarium, Pier 59, Seattle, WA 98101
ARTER, Hubert E., c/o A. Klug, Wilfredstrasse 19, CH-8032, Zurich, Switzerland
AVILES E., Prof. Miguel C., Apartado 6-765, Zona Postal El Dorado, Panama
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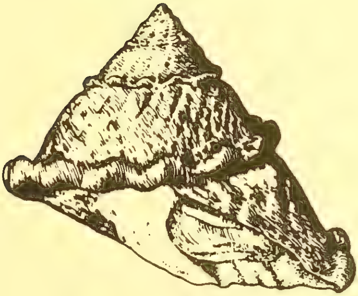

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The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the **Annual Report** is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $15.00 for regular members, $17.00 family, and $6.00 student.

The Western Society of Malacologists has issued two **Occasional Papers**— No. 1, "'Sea Shells of Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; and No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan.

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INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8½" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Research Associate, Dept. Invertebrate Zoology, Los Angeles County Natural History Museum, 900 Exposition Blvd., Los Angeles, California 90007.

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SHELLFISH MARICULTURE IN ALASKA

Michael Kaill
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There are four and possibly five species of shellfish that could be commercially cultured in Alaska. Critical issues are farm site selection, marketing, product form, cost-effective management, and permitting. Each of the five species are examined with reference to these issues.

BIVALVES FROM PRINCE WILLIAM SOUND, ALASKA

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Alaska's southcentral coast, including Prince William Sound, is subject to environmental change— both natural and human caused. The great earthquake of 1964 and last year's oil spill and clean up efforts are well known examples, but evidence of long term change, both climatological and geological, can also be seen as changes in the forest and erosion and deposition processes on the beaches.

Given this background, there is a need for a basic inventory of the biota of Prince William Sound.

Alaska's marine fauna is especially interesting and challenging because Alaska has many species in common with either the high Arctic regions, the temperate west Pacific Ocean or north Atlantic Ocean.

I list 122 bivalves. Fifty eight are found in the northeast Pacific, 20 have a panarctic and circumboreal distribution, 9 are amphiboreal, 6 are found in the Arctic as well as in the Northeast and Northwest Pacific Oceans, 9 seem to be endemic to the Aleutian province, 20 are common to the northeast and northwest Pacific oceans, and one species is introduced.

A few species are noteworthy as long standing identification problems: *Adontorhina cyclia* has been frequently misidentified as an *Axinopsida. Diplodonta* in Alaska is represented by two species, *D. aleutica* from Point Barrow to Sitka, and *D. impolita,* in Cook Inlet and Prince William Sound. Its exact distribution remains uncertain because of its misidentification as *D. orbella* or *D. aleutica.*

Part of the need for comprehensive study of the natural history of Alaskan molluscs is the need for revision and clarification in several taxa, among them, *Megayoldia, Musculus, Axinopsida,* and *Thyasira.*

SPATIAL AND TEMPORAL VARIABILITY OF BIVALVE MOLLUSKS IN THE WESTERN BEAUFORT SEA

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Bivalve molluscs across the continental slope in the Alaskan Arctic were sampled by Oregon State University from 1972 to 1980. In depth zones from 5-100 m, 52 bivalve species were recorded with densities up to 4,000 individuals/m^2. Bernard (1979) documented 58 bivalve species in depth zones from 0-2560 m. Carey *et al.* (1984) found bivalve distributions from 5-25 m to correspond with feeding type and sediment size.

Discreet assemblages across the continental shelf were found to directly correspond to feeding type, depth and sediment size. Nearshore waters from 5-10 m have coarse sediments and are dominated (60-80% of individuals and species) by filter feeders, with *Boreacola vadosa* Bernard, 1984 and *Liocyma fluctuosa* (Gould, 1841) being the most numerous. The finer sediments from 15-25 m were found to have over 95% deposit feeding individuals with *Portlandia arctica* (Gray, 1824) being numerically dominant.

Species diversity increases in depths between 40-100 m with filter feeding heterodonts accounting for 60-70% of the bivalves. *Astarte montagui* (Dillwyn, 1817) is common in this depth zone and comprises up to 25% of the bivalve numbers on the outer continental shelf.

From 1975 to 1976, four stations near Pitt Point were sampled in October, March, May and August. Significant seasonal variability was recorded at the 25 m station. October and March bivalve densities at 25 m were consistently around 200 individuals/m^2. Numbers drastically dropped in August to less than 50/m^2, possibly due to an influx of fresh water or ice gouging of the sediments. By contrast, a large pulse of bivalves at 25 m occurred in the summer with densities reaching over 400/m^2, seemingly a result of juvenile recruitment. Bivalve densities at 55 m, 70 m, and 100 m were fairly constant throughout all seasons ranging from 150-375 individuals/m^2. Slight increases in numbers were recorded in the spring and summer at 100 m.

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SEA STAR AND WALRUS PREDATION ON BIVALVES IN THE BERING SEA, ALASKA

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Soft-bottom bivalve communities were investigated in the Bering Sea, Alaska for four field seasons. The primary species studied were *Yoldia hyperborea, Macoma calcarea, Serripes groenlandicus*, and *Mya truncata*. Additional biological information was gathered on *Clinocardium* spp., *Tellina lutea*, and *Mactromeris polynyma*. Size class information revealed that most species exhibited a bimodal distribution with many smaller sizes, very few intermediate sizes, and some large sizes. The primary predator on smaller-sized bivalves was the sea star, *Asterias amurensis*. Laboratory experiments and field observations established that large bivalves have refuges from predation by sea stars. *Serripes groenlandicus* and *Clinocardium* utilize a behavioral leaping response to escape from sea stars while large *Yoldia hyperborea* and *Tellina lutea* are able to escape from sea stars by rapidly burrowing into the sediment. Large *Macoma calcarea* and *Mya truncata* live deep enough in sediment (>15 cm) to avoid capture by the shallow digging (<10 cm) sea stars. However, larger-sized bivalves were subjected to intense seasonal predation by walruses, *Odobenus rosmarus divergens*. Bivalves do not have a refuge from predation by walruses, but variations in the extent and distribution of the ice pack determine the areas where the majority of migrating walruses will feed.

NOTES ON NORTH PACIFIC GONATIDS: IDENTIFICATION OF BODY FRAGMENTS AND BEAKS FROM MARINE MAMMAL STOMACHS

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Basic to the identification of cephalopod remains from marine mammal stomachs is the preparation of a cephalopod reference collection and library. Presented here are a list of references that will be of use in developing a collection and will provide techniques useful in the examination of stomach contents, digestion rates and beak transit times in marine predators (sharks, fishes, mammals and birds). A sampling of literature on cephalopods from Alaskan waters and of subarctic Pacific marine mammals and their cephalopod prey is also presented. The literature cited sections of these papers will provide additional reference sources. The literature cited section of Okutani *et al.* (1988) is an excellent review of published information dealing with the family Gonatidae in the subarctic Pacific Ocean.

Preparation and storage of reference material.

The field collector should freeze cephalopods as taken for later identification in the laboratory. In the laboratory thaw, identify, sex and weigh specimens and measure mantle lengths. Other measurements and weights of organs can be made if desired. For extraction of beaks and radulae remove the buccal mass from thawed cephalopods and place in a jar of fresh water. After 4-5 days the beaks and radulae can be easily separated from the flesh and placed in 50% isopropyl or 70% ethyl alcohol. Remove statoliths, store dry in gelatin capsules. Remove gladii and store with preserved specimens. Whole specimens should be fixed in 10% formalin for 5-7 days and then transferred to either 50% isopropyl or 70% ethyl alcohol. See Roper and Sweeney (1983) for details.

Collection and storage of marine mammal and bird stomach remains, scats, and spewings.

Avoid preserving squids and fishes in formalin until after fish otoliths and cephalopod beaks and statoliths are removed. The stomachs of recently dead pinnipeds and small cetaceans can be removed whole and immediately frozen for later examination. The stomachs of long dead animals and birds, scats, and spewings should be cleaned as described by Treacy and Crawford (1981), after first making certain there are no identifiable flesh remains in the sample. Beaks, gladii and radulae can be placed in alcohol, while otoliths and statoliths should be stored dry in vials. Antonelis *et al.* (1987) discuss nonlethal techniques for obtaining stomach contents from living marine mammals.

Digestion and beak transit times.

The rate of digestion of the different species of cephalopods in marine mammal and bird stomachs varies. Cetaceans and pinnipeds whose stomachs contain relatively intact cephalopods when examined are generally considered to be feeding locally. Migrating animals might be an exception to this.

Bigg and Fawcett (1985), feeding Pacific herring (*Clupea herengus pallasi*) and market squid (*Loligo opalescens*) to captive northern fur seals (*Callorhinus ursinus*), reported that most squid remains were gone after 6 hours and all fleshy parts were digested within about 12 hours. They found squid beaks remaining in a stomach 33 hours after feeding. Clarke (1986a) discussed digestion and passage times of beaks in cetaceans. Furness *et al.* (1984) reported that beaks are known to have been retained in an albatross stomach for at least 50 days.

Examination of cephalopod material

Sort out complete specimens, taking care to preserve hooks and suckers on arms and tentacles, and identify by conventional means. Useful keys to cephalopods are found in Roper *et al.* (1984) and Nesis (1987). Separate arm crowns, buccal masses, gladii, beaks and statoliths. The flushing and sieving method described by Treacy and Crawford (1981) is excellent for retrieving hard parts but, before this is done, whole squids, arm crowns and buccal masses should be extracted. As the examination continues beaks can be separated from the contents but care should be taken not to destroy the beak wings, which are especially fragile in young specimens.

If whole specimens and arm crowns are in reasonably good condition it may be possible to identify them to family, genus and species. An examination of beaks and radulae from intact buccal masses should enable the investigator to assign them to family and, in the Gonatidae, to genus. Loose beaks can then be sorted to types and, by using Clarke (1986b), be assigned to family.

Members of the family Gonatidae comprise the most abundant cephalopod group in the epi- and meso-pelagic waters of the subarctic Pacific Ocean. A thorough review of the family Gonatidae of this region by Okutani *et al.* (1988) consolidates and summarizes our present knowledge of the family. Using material from their paper and other cited sources I have tabled information useful for identification of gonatid remains from marine mammal and bird stomachs (Table 1). Where mantle lengths larger than those listed by Okutani *et al.* (1988) are included in the table the source is noted. Species present in Alaskan waters are indicated. If known, the number of radular rows is given. References for species whose beaks have been illustrated are provided.

Discussion of gonatid beaks from North Pacific collections.

Information on gonatid beaks provided here is intended to complement Clarke (1986b). The discussion is based on examination of beaks from whole specimens of 9 of the 19 species listed by Okutani *et al.* (1988). Using lower beak characteristics, the gonatids examined form three general groups:

Group 1 (*Gonatus berryi, G. onyx, G. pyros,* and *Eogonatus tinro*). In squids in this group the lower beaks are laterally compressed to a markedly greater degree than in squids comprising Groups 2 and 3. The upper beaks also exhibit this characteristic and the upper beak rostrums are noticeably slimmer (lance-like) than those in Groups 2 and 3. In lower beaks, the angle of the rostral edge to wing is about 130 to 135 degrees. All beaks in this group had a lateral all fold, very slight in *G. berryi* and *G. onyx* and pronounced in *G. pyros* and *E. tinro*. All beaks exhibited a distinct rostral curve; however *E. tinro* was noticeably the least curved of the group.

When the darkened patch of the lower part of the wing joins the darkened part of the upper wing the wings are considered fully darkened. The lower beak wings of *G. berryi* are fully darkened at a lower rostral length (LRL) of 4.8 mm. One beak was partially darkened at a LRL of 4.0 mm. Data on individual specimens are on file at the National Marine Mammal Laboratory (NMML).

Group 2 (*Gonatopsis madokai* and *G. middendorffi*). The lower beaks of Group 2 squids are easily separated from Group 3 squids by the wing/rostral edge angle (group 2 = 135-140° vs group 3 = 90°) and from Group 1 squids because the lower beaks are not laterally compressed. Upper beaks of Group 2 squids do not exhibit the slim lance-like appearance of Group 1 squids. A shallow (slight, faint?) wall fold is present in the lower beaks of both species in this group. The lower beaks of *G. madokai* may have a slight hook at the rostral tip. The wings of *G. madokai* generally darken at a smaller LRL than those of *G. middendorffi*. Data on individual specimens are on file at the NMML.

Group 3 (*Gonatopsis borealis, Berryteuthis magister,* and *B. anonychus*). The lower beaks of Group 3 squids are easily separated from Groups 1 and 2 by the smaller wing/rostral edge angle of 90°. The lower and upper beaks of Group 3 squids are not compressed or lance-like. As illustrated in Clarke (1986b) other *Gonatopsis* (i.e. *makko, octopedatus* and *okutanii*) have wing/rostral edge angles of 120° or greater.

The beaks of *G. borealis, B. magister* and *B. anonychus* cannot be separated at some growth stages; however, if arm crowns are present *G. borealis* can be separated from *B. magister* and *B. anonychus* by the lack of tentacles. The flesh of the body and arm crown of *G. borealis* resist digestion to a greater degree and are usually present in marine mammal stomach contents long after all traces of *B. magister* flesh are gone.

The fragility of *B. magister* was demonstrated to me in 1981, when I examined a trawl catch of 13 *B. magister* and 7 *G. borealis* taken in the same tow. Both species had been frozen on the vessel and delivered to the laboratory in frozen condition. In the *B. magister* specimens the mantles were white in color, surface skin and chromatophores were gone, the tissue was soft and many tentacles were missing. In contrast, in the *G. borealis* specimens skin and chromatophores were present and the tissue was still firm. The beaks and radulae of *B. magister* were readily extracted during examination, whereas in *G. borealis* the beaks remained tight in the buccal masses and required soaking in fresh water for several days before they could be extracted.

The lower beaks of Group 3 squids are quite similar in appearance, but when fleshy remains are absent, the extent of wing darkening and LRL may be used to separate beaks within certain size ranges (Figure 1). For the following discussion only beaks from identified whole squids were examined and compared. Additional beaks and measurements are clearly needed to fill in size gaps and confirm present observations.

In *G. borealis* the lower beak wings are completely darkened in specimens with a LRL greater than 3.0 mm, the patch on the wing probably develops at about 2.5 mm and may persist to 3.0 mm. Wings are clear at least up to 2.2 mm LRL.

In *B. anonychus* the lower beak wings are completely darkened in specimens with a LRL larger than 1.5 mm, the patch on the wing is present at 1.3 mm LRL and may overlap slightly with complete darkening at 1.5 mm LRL.

In *B. magister* the lower beak wings are clear to about 3.2 mm LRL. The patch on the wing is present at about 3.6 mm and full darkening probably occurs some time after 4.0 mm LRL. More specimens need to be examined in the 3-7 mm LRL size range to confirm these meaurements.

Discussion of cephalopod statoliths from North Pacific collections

A number of statolith references are listed below, and additional information can be found in those references. Clarke (1978) described the method used to remove statoliths and illustrated and diagnosed their features. Clarke *et al.* (1980) also illustrated and defined the dimensions and descriptive terms for statoliths and, in addition, described and figured statoliths from *Berryteuthis magister, Gonatopsis borealis* and *Gonatus makko.* The NMML reference collection contains statoliths representing a few species and only three gonatids; *G. borealis, B. anonychus* and *B. magister.*

A gross examination of several statoliths from each of our gonatids demonstrated that the most obvious features of *Berryteuthis magister* are the large, rounded lateral dome and a long rostrum of about the same length as the dome. The lateral dome of *B. anonychus* is much smaller and not as rounded as in *B. magister.* The rostrum of *B. anonychus* exhibits a slight curve, whereas *B. magister* has a straight rostrum. In *Gonatopsis borealis* the proportions of the lateral dome are about half way between the two *Berryteuthis* species, while the rostrum is shorter and terminates in a point. The NMML statolith specimens of *G. borealis* and *B. magister* compare favorably with those illustrated in Clarke *et al.* (1980: Figs. 5, 7).

Cephalopod statoliths will likely be very useful in stomach content analysis as more statoliths from identified specimens become available. It would appear that there are enough differences between the statoliths of *Gonatopsis* and *Berryteuthis* to separate and identify them in stomach content materials.

Acknowledgements

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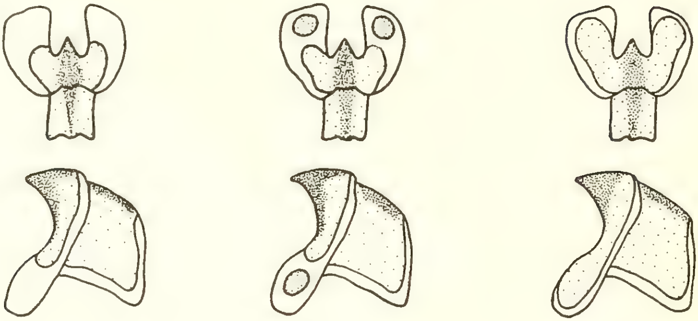
TABLE 1. SUMMARY OF USEFUL INFORMATION ON SUBARCTIC GONATIDAE

Genus/Species	**MKML**	**Ecol. type**	**AK**	*Useful information for identification*		
				Radular rows	**Beak type**	**Beak illus.**
Genus *Gonatus*						
G. berryi	199	A	*	5	G-1	1,2,3
G. californiensis	122	A		5		
G. madokai	329	A	*	5	G-2	1,2
G. middendorffi (NMML 263)	322	A	*	5	G-2	1,2
G. onyx	98	A	*	5	G-1	1,2
G. oregonensis	46	A		5		
G. pyros (NMML 380a)	92	A	*	5	G-1	1,2
G. ursabrunae	24	A	*	5		
G. sp. A Kubodera & Okutani	16		*			
G. sp. B Bublitz	79.6		*			
Genus *Eogonatus*						
E. tinro (NMML 411)	184	A	*	5	G-1	1
Genus *Gonatopsis*						
G. borealis (K & J 1984)	480	A	*	7	G-3	1,2,3
G. japonicus	166	B		5		
G. makko	350	B	*	7		1
G. octopedatus	240	B		5		1
G. okutanii	230	B	*	5		1
G. sp. A Kubodera	40					
Genus Berryteuthis						
B. anonychus (NMML 400)	183	A	*	7	G-3	1,2,3
B. magister (NMML 195a)	363	B	*	7	G-3	1,2

MKML: maximum known mantle length
NMML: National Marine Mammal Laboratory, specimen catalog number
K & J: Kubodera & Jefferts (1984)
Ecological type from Okutani *et al.* 1988:
A = muscular, epipelagic to mesopelagic, eurybathic
B = less muscular, stenobathic, nektobenthic
AK: *known from Alaskan waters
Beak types: Groups 1, 2 or 3 (see text)
Beak illustrations: 1 = Clarke (1986); 2 = Kubodera & Furuhashi (1987); 3 = Iverson & Pinkas (1971)

Figure 1: Wing darkening in lower beaks of Group 3 gonatid squids.



Gonatopsis borealis

ML	39-107	124	>130
LRL	<2.2	3.0	>3.0
HL	<3.0	3.5	>5
CL	<6.0	8.5	>10.5
No.	4	1	6

Berryteuthis anonychus

ML	<70	75-83	>83
LRL	<1.3	1.3-1.5	>1.5
HL	<2.0	2.0	>2.5
CL	<3.0	3.5	>4.0
No.	1	6	4

Berryteuthis magister

ML	<153	—	>238
LRL	<3.2	3.6	>4.0
HL	<4.0	—	7.0
CL	<9.0	—	>17.0
No.	4	—	2

ML = mantle length
LRL = lower rostral length
HL = hood length
CL = crest length

LAND SNAILS FROM RAMPART CAVE 1, NORTHEAST ALASKA

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Quaternary sediments in Lower Rampart Cave 1 yielded a collection of land snails more diverse than that from any other terrestrial locality in eastern Beringia. Shells and shell fragments were extracted from 27 of 45 bulk samples of stratified, matrix-supported angulary gravels. The cave is perched on a south-facing xeric escarpment surrounded by dense spruce forest in northeast interior Alaska. A radiocarbon date of 22,000 yr B.P. stratigraphically below the shells provides a lower limiting date, and shells recovered from sediments above a date of 3,500 yr B.P. suggest that some taxa lived in the Porcupine River Valley until modern times. The stratigraphic occurrence suggests that the fauna is post-glacial in age.

The fauna is composed of six species belonging to five genera: *Vertigo modesta*; *Vertigo* sp., *cf. V. gouldi*; *Vallonia* sp., *cf. V. costata*; *Discus whitneyi*; *Succinea* sp., *cf. S. strigata*; and *Euconulus fulvus* (Figure 1). *Vertigo* and *Vallonia* were most abundant, ribbed fragments of *Discus* were common, and *Succinea* and *Euconulus* were moderately frequent.

Euconulus fulvus, Vallonia sp., *cf. V. costata,* and *Succinea* sp., *cf. S. strigata* were found in modern surface samples collected from colluvial sediments adjacent to the cave. The modern surface assemblage represents a talus habitat, while the cave assemblage is representative of meadow or marsh-edge habitat. The fauna from the cave is consistent with forested conditions, but not necessarily diagnostic of them.

Vallonia costata is not known from eastern Beringia, and the present samples of *Vallonia* differ in details of shape and sculpture from modern cordilleran specimens of *V. costata.* These distinctions suggest that the Rampart Cave *Vallonia* may have evolved locally in a glacial refugium.

The snails from Rampart Cave 1 represent taxa that inhabited, or reinhabited, central Alaska after the disappearance of late Wisconsin glacial ice. The diverse record of terrestrial molluscs suggests the sudden appearance of a snail fauna soon after deglaciation.

Acknowledgments

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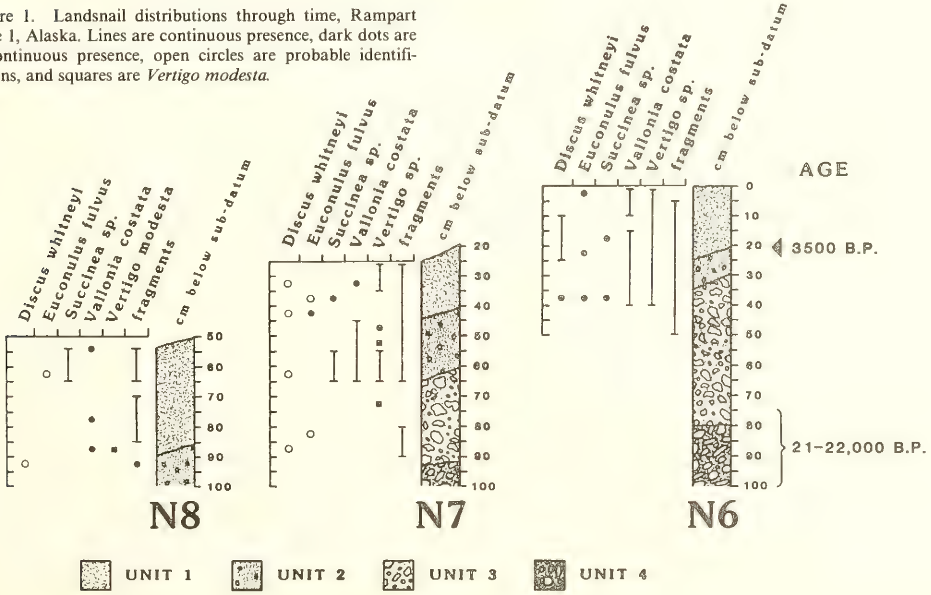
Figure 1. Landsnail distributions through time, Rampart Cave 1, Alaska. Lines are continuous presence, dark dots are discontinuous presence, open circles are probable identifications, and squares are *Vertigo modesta.*



ASPECTS OF THE BIOGEOGRAPHY OF ALASKAN OENOPOTINAE MOLLUSKS

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The subfamily Oenopotinae (Gastropoda: Prosobranchia: Turridae) appears to have a center of adaptive radiation in southcentral Alaskan waters. Demersal development and habitat specialization probably have been major factors in the immense amount of speciation seen in this region.

BIOGEOGRAPHY OF ALASKAN OPISTHOBRANCHS

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There are 88 species of benthic opisthobranchs recorded for Alaskan waters. Compared to warm temperate and tropical waters, Alaska has a depauperate opisthobranch fauna with about one quarter of the recorded species diversity. In this study, the opisthobranch fauna was divided into taxonomic orders and compared with their proportions in other areas, as compiled by Bertsch (1973, 1985), Bertsch & Johnson (1983), Millen (1983, present study).

The Bullomorpha make up 24% of the Alaskan opisthobranchs. This is a relatively high proportion, equaled in the Antarctic and slightly exceeded in the rich Panamic fauna, but greater than in intermediate areas. It appears that some genera have diversified in the tropics and others at each polar region, and that this diversity has decreased towards the temperate zones. The herbivorous opisthobranchs are tropical in origin. Alaska has no representatives of the order Anaspidea (the sea hares and their kin), and only three species of the inconspicuous order Sacoglossa, although the remaining five cold temperate sacoglossans are predicted to occur in southern Alaska. Order Notaspidea, the side-gill slugs, is poorly represented in the opisthobranch fauna, both in Alaska and worldwide, except in the Antarctic. Nudibranchs are the dominant group worldwide, and the proportion in Alaska, 71%, is similar to that found in both temperate and tropical areas. Within the order, the proportion of dendronotids is relatively high and that of aeolids is relatively low.

Alaskan opisthobranchs are primarily endemic. Forty seven percent are endemic to the northeastern Pacific where they generally range from the Aleutians to southern California or the Gulf of California. Only a few end their range at the junction of the Aleutian and the Oregonian faunal provinces. Of the 21% of the species which are subarctic, 25% are endemic to the Bering Sea, the rest having affinities with other Arctic areas or the Atlantic. Circum-Pacific distributions are found in 19% of the species, 5 of which are also amphi-Atlantic, and can therefore be regarded as truly circumboreal. Thirteen percent of Alaskan opisthobranchs are found to have boreal distributions in the eastern Pacific and in the amphi-Atlantic. Combined with the circumboreal species and Arctic species which extend to the Atlantic, a total of 24% of Alaskan opisthobranchs also have amphi-Atlantic distributions. Several scenarios for this strong Atlantic link are possible.

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ORIGIN OF THE MODERN GULF OF ALASKA COLD-WATER MOLLUSCAN FAUNA

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The Gulf of Alaska is a broad embayment of 55° to 60° north latitude that extends about 1,800 kilometers along the coast of southern Alaska, from the western end of the Alaska Peninsula to central British Columbia, Canada (Figure 1). Both the shallow- and deep-water modern molluscan faunas of this vast and biogeographically central region have been little studied owing to the frigid climate and oceanographic conditions that make collecting both difficult and dangerous. However, the Gulf of Alaska molluscan fauna has not always been a cold-water one, but at times in the geological past contained taxa that imply much warmer conditions. Prior to about 15 or 16 Ma (million years ago) faunas representing tropical to mild-temperate conditions dwelled in what is now a prohibitively cold region.

Molluscs of all Cenozoic epochs are present in southern Alaska, but there is little evidence of molluscs of the Paleocene Epoch (the earliest part of the Cenozoic Era in which we still live). The Paleocene is represented at only one site in southern Alaska, where the characteristic late Paleocene gastropod *Turritella merriami brevitabulata* occurs in the Kulthieth Formation (Addicott and Plafker, 1972). This *Turritella* species is otherwise known only in late Paleocene faunas of northern California. The modern northern range-limit of *Turritella* is Monterey, California, which suggests that the late Paleocene ocean in southern Alaska was within the mild-temperate province.

The succeeding, Eocene epoch saw the worldwide development of the warmest climates that existed during the Cenozoic. Tropical seas extended to southern Alaska and genera such as *Dosinia, Macrocallista, Pitar,* ornamented *Conus, Ficus,* and large turritellas are common in several formations. Eocene climates were so warm that even single species had very broad geographic distributions. For example, of the nine molluscs identified to species in upper middle Eocene rocks of the Tolstoi Formation of southwestern Alaska, seven occur in coeval rocks of the Cowlitz Formation of Washington, six in the lower to upper(?) Eocene Tejon Formation of southern and central California, and at least two in faunas of Chukotka and West Kamchatka, U.S.S.R. (Marincovich, 1988). Most Eocene molluscan faunas in southern Alaska have not been studied in detail, but it is clear that none of the modern cold-water Gulf of Alaska taxa had ancestors in these ancient tropical faunas.

After the Eocene climatic maximum, southern Alaskan faunas reflect general global cooling. Molluscan faunas of the succeeding Oligocene epoch are relatively well known in the Stepovak Formation of the western Gulf of Alaska and in the Poul Creek Formation of the eastern Gulf of Alaska. In both formations, which are largely of Oligocene age, faunas are less diverse than during the Eocene and contain greater percentages of endemic species. The southern Alaskan marine climate probably was mild-temperate for much of the Oligocene. A number of species co-occur in Alaskan and Pacific Northwest faunas on one side, and in Alaskan and eastern Asian faunas on the other (Kanno, 1971). The fact that virtually no Oligocene species range from the Pacific Northwest to eastern Asia is evidence for a cooler North Pacific climate. Taxa such as the bivalves *Cyclocardia ezoensis, Ostrea gackhensis, Papyridea harrimani,* and the gastropods *Liracassis apta,* and *Trominina* spp. are ties from eastern Asia to the Stepovak fauna of the western Gulf of Alaska. On the other hand, Gulf of Alaska bivalves such as *Crassatella washingtoniana, Tellina cowlitzensis arnoldi, Macrocallista weaveri* and *Panope snohomishensis,* and gastropods such as *Turricula washingtoniana* and *Liracassis apta* are Oligocene ties to the faunas of Oregon and Washington. *Liracassis apta* is one of the very few Oligocene molluscs reported to range from Asia to the Pacific Northwest. The beginnings of lineages that extend to the modern day in the Gulf of Alaska may be seen in the first appearance in significant numbers of *Neptunea, Mya, Panomya, Panope, Periploma* and *Yoldia* species.

The marine climate at the end of Oligocene and the beginning of the Miocene is evidenced by the fauna of the Narrow Cape Formation of Sitkinak Island, in the western Gulf of Alaska (Figure 1). The Sitkinak Island fauna contains many endemic Alaskan species and few Asian and Pacific Northwest species (Allison and Marincovich, 1981). However, both endemic and widespread species belong to genera that are associated with relatively cold environments. Principal among these are the gastropods *Ancistrolepis, Buccinum* and *Priscofusus,* and the bivalves *Hiatella, Mya,* and *Periploma.* All of these genera are present in the modern Gulf of Alaska fauna, and some are still represented by the same species as in the Sitkinak Island fauna.

The trend toward increased climatic cooling continued through the early Miocene, then dramatically intensified at the beginning of the middle Miocene at about 15-16 Ma. This abrupt cooling was directly related to the uplift of the present coastal Chugach and St. Elias Mountains (Marincovich, in press). These mountains had been rising since at least the late Oligocene in response to the impact against southern Alaska of a northward-moving tectonic plate, the Yakutat terrane (Plafker, 1987). The elevation of these coastal mountains (to 6,000 meters currently) allowed the development of alpine glaciers and, ultimately, coastal glaciers that formed along the northeastern Gulf of Alaska margin. The onset of coastal glaciation is seen in the presence of ice-rafted dropstones and other glacial lithologies associated with early middle Miocene molluscan faunas in the Yakataga Formation (Kanno, 1971; Plafker, 1987; Marincovich, in press). The species composition of early middle Miocene Yakataga faunas is essentially that of the modern Gulf of Alaska. Faunal changes have occurred during the past 15 or 16 million years only in response to brief warming episodes. Even the onset of Ice Age glaciation about two million years ago had little effect on Gulf of Alsaka faunas, because they already had been living in an ice-dominated oceanographic regime for at least 13 million years.

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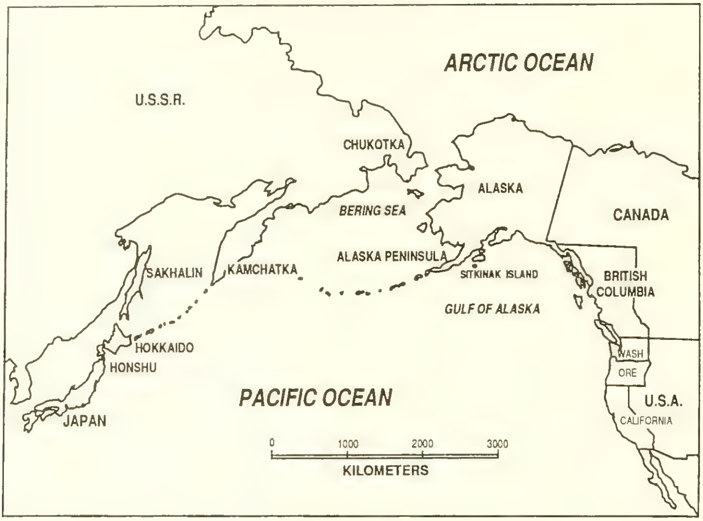

Figure 1. Index map showing location of the Gulf of Alaska.

PLIOCENE AND PLEISTOCENE MOLLUSCS IN MARINE TRANSGRESSIONS OF WESTERN AND NORTHERN ALASKA

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Introduction

Pliocene and Pleistocene marine deposits mantle coastal areas of western and northern Alaska from the Bering Strait region north- and eastward to the Canadian border (Figure 1). These sediments record the episodic regressions and transgressions of the sea that accompanied the waxing and waning of polar ice sheets and continental glaciers. Transgressions occurred when sea level rose high enough to flood Bering Strait and join the North Pacific and Arctic Oceans, and regressions were times when the land connection between Siberia and Alaska was reestablished. Molluscs are abundant and diverse in these deposits and have been used to date individual transgressions and to correlate geographically widespread transgressive deposits. Most species in these relatively young deposits still live in the adjacent Bering Sea and Arctic Ocean, so only a few species are useful for dating or correlation. Conversely, the high percentage of living species aids in accurate determinations of paleoenvironments.

Pliocene and Pleistocene marine sediments are discontinuous and widely distributed in western and northern Alaska. Sediments and faunas of the Seward Peninsula and adjacent areas in western Alaska (Figure 1) were studied earlier than those in northern Alaska, and geological and paleontological studies of western and northern Alaskan deposits mostly have been conducted by different workers. As a result, different lithostratigraphic and biostratigraphic schemes have been established for each region. Current work is aimed at integrating these two schemes, but it more accurately reflects current knowledge to treat western and northern Alaskan deposits separately here.

In recent years the use of amino acid racemization studies for relative age-dating (Brigham, 1985; Huston and others, in press), and strontium isotope studies for absolute age dating of molluscs and microfossils (Kaufman *et al.*, 1990) have significantly changed our understanding of both western and northern Alaskan transgressions (Table 1). These techniques and other, more esoteric, ones such as thermoluminescence and electron spin resonance, are expected to aid greatly in achieving a unified biostratigraphy for western and northern Alaskan Pliocene and Pleistocene faunas in the future.

Western Alaska

Miners had long known of fossils in coastal deposits on the Seward Peninsula at Nome, where they regularly encountered shells while sifting and mining beach sand and gravel for gold. Dall (1920) was the first to extensively study these deposits and to attempt to discriminate lithological units, partly based on their molluscan faunas. Dall's (1920) subdivision of these Pliocene and Pleistocene deposits was followed by MacNeil *et al.* (1943). However, no further extensive analysis and synthesis of the Nome deposits was attempted until Hopkins (1965, 1967) proposed formal names for seven marine transgressions (Table 1). Continued studies by Hopkins and other workers (Hopkins *et al.*, 1972, 1974; Brouwers *et al.*, 1984; Kaufman *et al.*, 1989; Huston *et al.*, in press) resulted in refinement of the ages and stratigraphy of western Alaskan transgressions. Six marine transgressions, ranging in age from about 3.5 Ma to less than 4,000 years, currently are recognized on the Seward Peninsula (Table 1). Each transgression is thought to be characterized by mollusc species of limited stratigraphic distribution (Table 2). Some of these species are extinct, and others are living but of relatively warm-water aspect and migrated north to the Bering Strait region during warm climatic intervals. Thus, living midlatitude species such as *Natica janthostoma* and *Protothaca adamsi* characterize certain transgressions (Table 2).

Northern Alaska

Relatively young fossil molluscs have long been known from northern Alaska (Dall, 1919; Leffingwell, 1919), but the remoteness, lack of a road network, and the very short open season deterred extensive studies until the 1970's. Pliocene and Pleistocene deposits that crop out on the Arctic Coastal Plain of Alaska, from the Chukchi Sea in the west to the Beaufort Sea in the east (Figure 1), are included in the Gubik Formation (Black, 1964). The most comprehensive taxonomic work on Gubik molluscs is that of MacNeil (1957), although an understanding of Gubik biostratigraphy and, therefore, relative ages of transgressive faunas has developed only during the past two decades. Due to the vast and isolated geographic region in which Gubik deposits crop out, individual studies of Gubik molluscs have necessarily been of limited scope. The most intensive work done on Gubik litho- and biostratigraphy is that of Brigham (1985), who studied coastal exposures at Skull Cliff, which extends for about 50 kilometers along the eastern margin of the Chukchi Sea south of Barrow (Figure 1). The five marine transgressions she recognized at Skull Cliff can now be tentatively correlated with those of the Seward Peninsula - Kotzebue Sound area (Kaufman *et al.*, 1990; Huston *et al.*, in press) and with the older five of the eight units recognized farther east on the Arctic Coastal Plain (Carter *et al.*, 1986; D.M. Hopkins, written commun., 1990) (Table 1). These correlations are based on faunal studies and amino acid relative dating of molluscs and microfossils. Extinct and southern extralimital molluscs are recognized in some Skull Cliff faunas (Brouwers *et al.*, 1984; Brigham, 1985) which supports faunal correlations with faunas of the Seward Peninsula (Brigham, 1983). Similar correlations have been made with Gubik units on the eastern part of the Arctic Coastal Plain (Carter *et al.*, 1986) (Table 1), where molluscan faunas have been documented in more detail (Table 3).

Studies of Bering Sea and Arctic Ocean Pliocene and Pleistocene molluscan faunas are currently in a transitional stage. Earlier studies that defined transgressions entirely on lithologic or lithologic and faunal bases have been superseded by studies that include relative dating based on amino acid racemization and certain absolute dating techniques. In addition, all western and northern Alaskan mollusc faunas that have previously been identified by several generations of paleontologists are now being reidentified by the present authors in order to rationalize their taxonomy. Pliocene and Pleistocene molluscan faunas are known from more than 600 localities in western and northern Alaska and consist of at least 150 species. Once fully identified and combined with relative and absolute age data, these faunas will provide a vivid picture of the openings and closings of Bering Strait that began about 3.5 million years ago.

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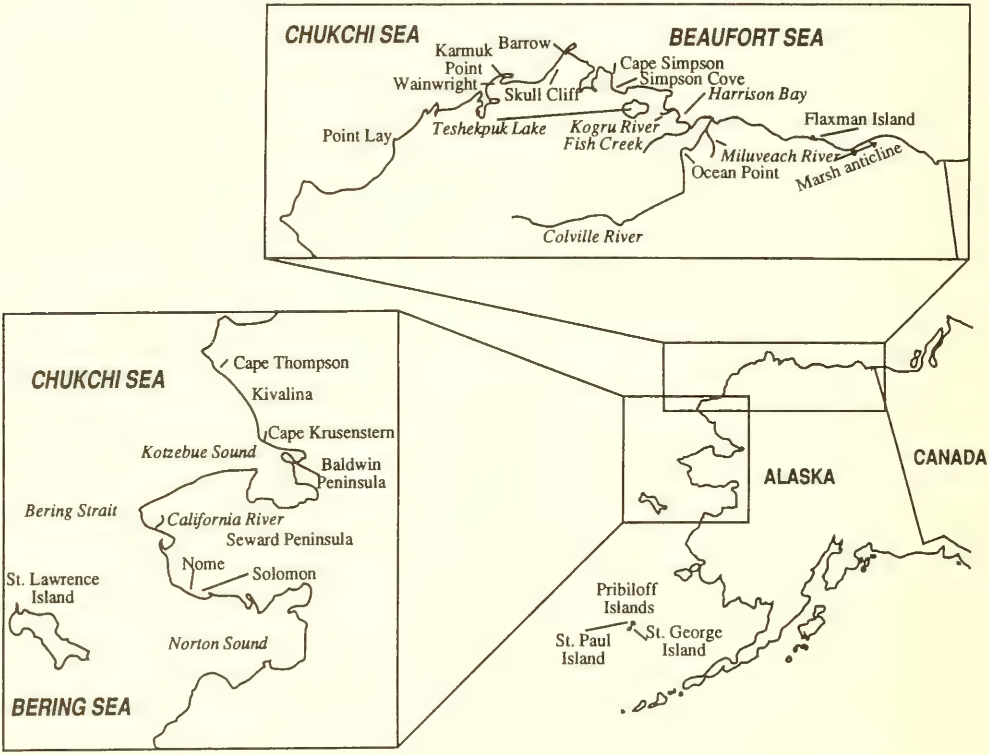

Figure 1. Location map showing western and northern Alaska.

Table 1: Correlation of Pliocene and Pleistocene marine transgressions of western and northern Alaska.

Age (Hopkins, 1965; 1967 and Carter *et al.*, 1986)	**Bering Sea** (Kaufman *et al.*, 1989 and Hopkins, written comm., 1990)	**Westrn and Northern Alaska** (Brouwers *et al.*, 1984)	**Skull Cliff** (Brigham, 1985)	**Arctic Coastal Plain** (Carter *et al.*, 1986)
<4 ka	Krusensternian	Flandrian	—	Flandrian
ca. 25 ka	—	—	—	middle Wisconsin
90-105 ka	—	Flaxman Fm.	—	Simpsonian
120-130 ka	Pelukian	Pelukian	Walakpa beds	Pelukian
ca. 500 ka	Anvilian	Kotzebuan	Karmuk beds	Wainwrightian
>1.5 & <2.4 Ma	Beringian III	Fishcreekian	Tuapaktushak b.	Fishcreekian
>2.4 Ma	Beringian II	Anvilian	Killi Creek beds	Bigbendian
<3.5 Ma	Beringian I	Beringian	Nulavik beds	Colvillian

Table 2: Preliminary table of age diagnostic and ecologically significant molluscs in western Alaskan marine transgressions (Modified from Hopkins, 1967).

Taxa/Transgressions	Beringian I, II, and III	Anvilian	Pelukian	Krusensternian
BIVALVIA:				
Astarte actis	-	x	-	-
Astarte bowersi	x	?	-	-
Astarte diversa	-	x	-	-
Astarte hemicymata	x	x	-	-
Astarte leffingwelli	x	x	-	-
Astarte nortonensis	x	x	-	-
Chlamys beringiana colvillensis	x	x	-	-
Chlamys coatsi	-	x	-	-
Chlamys coatsi middletonensis	-	x	-	-
Chlamys islandica kanagae	x	?	-	-
Chlamys islandica powersi	-	?	-	-
Chlamys lioica	?	x	-	-
Chlamys plafkeri	-	?	-	-
Chlamys tugidakensis	x	-	-	-
Fortipecten hallae	x	-	-	-
Portlandia arctica	-	-	x	x
Protothaca adamsi	-	-	x	-
Swiftopecten kindleri	-	x	-	-
Tellina lutea alternidentata	-	x	x	x
Yoldia kuluntunensis	x	-	-	-
GASTROPODA:				
Boreotrophon kamchatkanus	x	-	-	-
Littorina spp.	-	x	x	-
Natica janthostoma	-	x	x	-
Neptunea heros mesleri	x	x	-	-
Pyrulofusus schranderi	x	-	-	-

Table 3: Preliminary table of age diagnostic and ecologically significant mollusc occurrences in northern Alaskan marine transgressions.

Taxa/Transgression	Colvillian	Bigbendian	Fishcreekian	Wainwrightian	Pelukian	Simpsonian
BIVALVIA:						
Astarte bowersi	cf.	-	-	-	-	-
Astarte leffingwelli	x	x	-	-	-	-
Bathyarca glaciale	-	-	-	-	-	x
Chlamys beringiana colvillensis		x	-	-	-	-
Clinocardium californiense	-	-	x	-	-	-
Cyrtodaria kurriana	-	-	-	-	-	-
Fortipecten hallae	x	-	-	-	-	-
Mytilus sp.	-	x	-	-	-	-
Portlandia arctica	-	-	-	-	-	x
Siliqua spp.	x	-	-	-	x[1]	-
Spisula polynyma	-	-	-	-	x[1]	-
Tellina lutea alternidentata	-	-	-	-	x[1]	
Zirfaea pilsbryi	x	-	-	-	-	-
GASTROPODA:						
Aforia circinata	-	x	x	-	-	-
Amauropsis islandica	-	-	-	-	-	-
Antiplanes piona	-	cf.	-	-	-	-
Liomesus ooides	-	-	x	-	x[1]	-
Littorina squalida	-	x	x	?	-	-
Natica janthostoma	-	-	x	-	x[1]	-
Neptunea beringiana	cf	cf	cf	-	-	-
N. lyrata leffingwelli	x	x	x	-	-	-
Plicifusus cf. *P. brunneus*	x	-	x	-	-	-
Polinices n. sp.?	x	x	x	?	x[1]	-
Pyrofusus deformis	-	-	-	-	x	-
Pyrofusus schranderi	x	-	-	-	-	-

[1] - from Hopkins and Marincovich (1981) for deposits outside the type locality.

ORDOVICIAN GASTROPODS FROM ALASKA

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Ordovician gastropods known from several areas in Alaska appear to represent a relatively cosmopolitan assemblage. The lithology and associated faunas of these gastropod localities suggest warm, very shallow, possibly restricted marine environments of deposition. The similarity of the faunas indicate that the various tectonic "terranes" suggested by others do not represent crustal blocks that have been transported for great distances (several thousand kilometers) from different regions.

The first Lower and Middle Ordovician gastropods to have been described from Alaska are from Telsitna Ridge in the Medfra quadrangle of west-central Alaska (Rohr and Blodgett, 1988; Rohr, Blodgett, and Dutro, in prep.). *Helicotoma medfraensis* Rohr and Blodgett, 1988, represents a genus that is relatively widespread in Ordovician carbonate rocks, except for those in the northern and eastern Soviet Union and Western and arctic North America, where only one other occurrence is known. Several forms of macluritacean opercula are present, some of which appear to correspond to shells of *Maclurites* present in the same beds and others of which are of uncertain macluritacean affinities. Lower Middle Ordovican macluritacean opercula are very similar to opercula known from the interval from Alabama and Malayasia. Other Middle Ordovician gastropods present include *Maclurites* sp. and *Scalites?* sp. nov.

Also from west-central Alaska, Rohr and Blodgett (1985), reported the genera *Trochonemella, Maclurites, Euomphalopterus, Pseudophorus, Oriostoma,* and *Siskiyouspira* from the Upper Ordovician at Lone Mountain in the McGrath quadrangle. Additional unpublished collections contain n. gen. aff. *Tropidodiscus, Paraliospira* spp., *Liospira* sp., *Lophospira* sp., and the small gastropod operculum *Rousseauspira* sp.

In the White Mountains of east-central Alaska, Blodgett *et al.* (1987) recovered *Maclurites* cf. *M. manitobensis, Trochonemella* sp., and *Liospira* sp. from the Upper Ordovician Fossil Creek Volcanics.

A faunule from the Upper Ordovician (Ashgill) part of the Nanook Formation in the Shublik Mountains of the Brooks Range is the northernmost Ordovician fossil locality known from the United States (Blodgett *et al.*, 1988). Gastropods present include *Maclurites* sp., *Ectomaria* cf. *E. prisca, Murchisonia?* sp., and the distinctive pleurotomariacean *Siskiyouspira* Rohr, 1980. Elsewhere, *Siskiyouspira* is known only from west-central Alaska and the Brooks Range, as well as northern California.

The most diverse Ordovician gastropod fauna from Alaska is from the Seward Peninsula (the westernmost Ordovician rocks in North America) where 33 species of Upper Ordovician gastropods were recently described (Rohr and Potter, 1987; Rohr, 1988). Newly described species included *Helicotoma blodgetti, H. robinsoni, Ecculiomphalus? potteri, Pachystrophia spiralis, Raphistoma tellerensis, Trochonemella reusingi,* and the gastropod operculum *Rousseauspira. Sinutropis,* previously known only from the Upper Silurian of Bohemia, was found as were *Daidia* and *Ophiletina* which previously were known only from the Middle Ordovician of eastern North America. *Euomphalopterus (Euomphalopterus) alata,* present in the Seward Peninsula, represents a genus not normally found until the Silurian. The Seward Peninsula fauna shares some uncommon taxa with the Middle Ordovician of the Ottawa Valley (Wilson, 1951; Steele and Sinclair, 1971), including *Daidia, Trochonemella,* and *Straparollina,* as well as several cosmopolitan genera similar to other Middle and Upper Ordovician North American faunas.

The only other area in western North America having a large number of Ordovician gastropod taxa is the Klamath Mountains of California (Rohr, 1980). Taxa in common with Alaska include *Tropidodiscus, Maclurites, Helicotoma, Ophiletina, Lytospira, Pachystrophia, Liospira, Paraliospira, Loxoplocus* (*Lophospira*), *Trochonemella, Euomphalopterus?, Trochonema, Gyronema, Murchisonia, Ectomaria, Subulites* (*Cyrtospira*), and *S.* (*Fusispira*). Ordovician gastropod faunas from the Great Basin are very poorly known except for *Maclurites* and *Palliseria.*

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SILURIAN AND DEVONIAN GASTROPODS OF ALASKA

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Silurian gastropods from Alaska are poorly known and present a fruitful area for future study. The only species ever described from the Silurian of Alaska is *Bathmopterus liratus* Kirk, 1928, which was erected as the type and only known species of the genus *Bathmopterus* Kirk. This genus is a junior subjective synonym of *Euomphalopterus* (*Euomphalopterus*). *Euomphalopterus* (*E*). *liratus* is found in Upper Silurian limestones of Willoughby Island, Glacier Bay, southeastern Alaska. Other large, abundant, undescribed gastropod species, including representatives of several new, unnamed genera, are found at the same locality. The paleoecological setting of this fauna is uncertain. Late Silurian level-bottom, lagoonal assemblages containing abundant and diverse undescribed gastropod faunas are known from the vicinity of Marble Island, southeastern Alaska. In southwestern and west-central Alaska, Upper Silurian algal reefs have local pockets rich in monotaxic accumulations of gastropods.

Alaskan Lower Devonian gastropods are known from a number of recently assembled collections but require further study. Biogeographically they have a strong affinity with the Old World Realm (Blodgett *et al.*, 1989, 1990). Only a single gastropod species has been described from the Lower Devonian of Alaska, *Chlupacispira spinosa* Blodgett & Rohr, 1989, from Emsian (late Early Devonian) beds on the southern flank of Limestone Mountain, Medfra B-4 quadrangle, west-central Alaska. This same locality yielded more than 35 other species, including representatives of distinctive Old World Realm character like *Beraunia, Euomphalopterus, Hesperiella, Oriostoma,* and *Sinistracirsa.* Emsian gastropods occur in reefal or perireefal environments in the Ogilvie Formation, Charley River A-1 quadrangle, east-central Alaska. Oriostomatids (including at least two new genera), *Spirina* and *Boiotremus* are especially notable here. Emsian gastropods are also common on Kasaan Island, southeastern Alaska, and include Old World Realm taxa like *Oriostoma* and *Tubina.* Biogeographically distinctive gastropods were illustrated in Blodgett *et al.* (1989) from all of the above-cited Lower Devonian localities.

Eifelian (early Middle Devonian) gastropods are abundant and diverse in Alaska. A large faunule that has 35 species is known from the Livengood quadrangle, east-central Alaska (Blodgett, in press). Prominent taxa in the faunule include representatives of *Bellerophon* (*Bellerophon*), *Mastigospira,* a new genus with aff. to *Omphalotrochus, Buechelia,* a new genus with aff. to *Loxonema,* and a possible pseudozygopleurid new genus. The most diverse Eifelian gastropod fauna is that from the upper part of the Cheeneetnuk Limestone, McGrath quadrangle, west-central Alaska. Over 70 species are present, but only one species, *Spinulrichospira cheeneetnukensis* Blodgett & Rohr, 1989, has been described. Many of the Cheeneetnuk gastropod species are also present in the coeval Livengood Quadrangle fauna. A number of brachiopod and calcareous algal species are also found in both faunas. Many of these same faunal elements (both gastropods and brachiopods) also occur in small collections from the Eifelian of southeastern Alaska. On the basis of the high number of shared endemic gastropod species, interior and southeastern Alaska have been united into a single Eifelian biogeographic province, termed the Alaska-Yukon Province (Blodgett *et al.*, 1990). The strong faunal similarities found throughout this region do not support tectonic models favoring long-distance transport of "tectonostratigraphic terranes" from disparate sources. Givetian (late Middle Devonian) gastropods of Alaska are presently known in too few numbers to be of significance.

Upper Devonian gastropods from Alaska remain poorly known and have no known descriptions or illustrations. Frasnian (early late Devonian) gastropods occur commonly in carbonate strata of the Lime Hills quadrangle, southwestern Alaska, and the widespread genus *Orecopia,* which occurs at numerous localities in western North America, appears to be represented here by a new species.

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TERRESTRIAL SLUGS OF THE PACIFIC NORTHWEST (PULMONATA: STYLOMMATOPHORA)

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University of Washington
Seattle, Washington

Terrestrial slugs thrive in the moist, temperate Pacific Northwest lowlands. Their success depends on remarkable mucus secretions, other defense mechanisms, and complicated adaptive behavior.

ADDITIONS TO THE AGLAJIDAE (OPISTHOBRANCHIA: CEPHALASPIDEA) OF THE INDO-PACIFIC

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Recent collections of opisthobranchs from Papua New Guinea, Madagascar, and Hawaii have yielded specimens of 19 species of aglajids. Several of these collections represent significant extensions of the known ranges of these species. *Chelidonura electra* Rudman, 1970, previously known only from the western Pacific from the type locality in the Solomon Islands, has been collected from Papua New Gunea and the southwest coast of Madagascar. *Philinopsis reticulata* (Eliot, 1903) was known only from a single specimen collected from Zanzibar. Hank Chaney collected a living specimen from coarse sand, off Isle Ste. Marie, Madagascar. The genus *Nakamigawaia* Kuroda & Habe in Habe, 1961, contains only one described species, *N. spiralis* Kuroda & Habe in Habe, 1961. A second member of this genus has been found commonly in Papua New Guinea and Madagascar. Four undescribed species of *Chelidonura* have been collected from Papua New Guinea. One of these has also been collected from Madagascar. An additional undescribed species of *Chelidonura* has been collected from the Hawaiian Islands.

CONTACT ASSOCIATION BETWEEN THE NUDIBRANCH *GYMNODORIS NIGRICOLOR* BABA, 1960 (GYMNODORIDIDAE) AND THE DATEHAZE GOBY (PERCIFORMES: GOBIIDAE)

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The Gymnodorididae is a moderately diverse, tropically centered family. The gills rise in a crescent across the back rather than forming a close bunch as in the polyceratids. They possess a broad radula with numerous hooked teeth. They feed on a variety of organisms. Many have been observed feeding on other opisthobranchs.

In June 1985, Ernest Williams, a fish parasitologist, was doing research at the Sesoko Marine Science Center in Okinawa. While diving in the vicinity of the marine laboratory, on four occasions he observed a black nudibranch clinging to the datehaze goby, *Amblyeleotris japonica* Takagi. He reported his observations in The Venus (Williams & Williams, 1986).

Recently, Dr. Robert Bolland, of the University of Maryland, has discovered several colonies of these symbionts (Figures 1 and 2) in Seragaki Bay, Okinawa. The nudibranch is here identified as *Gymnodoris nigricolor* Baba, 1960. The main colonies are at 30 to 50 feet deep. The normal snapping shrimp symbiont of the goby is also found in the burrows. The association of the nudibranch and the goby is seasonal. Dr. Bolland found them from December through May. The nudibranchs disappear as the water warmed up.

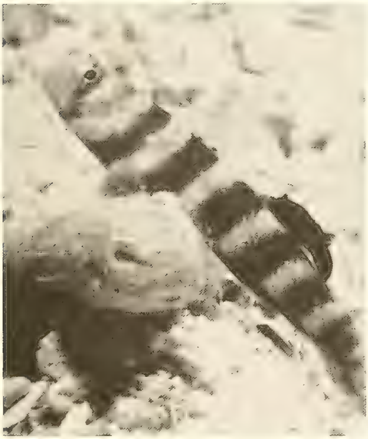

Figure 1. Datehaze goby fish, *Amblyeleotris japonica*, with symbiotic nudibranch. Photo by R. Bolland.

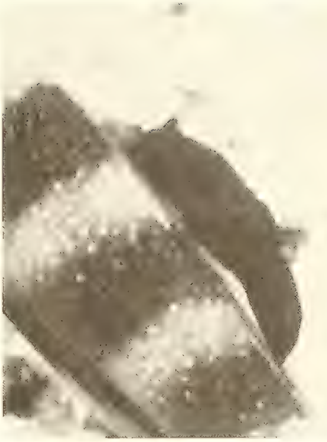

Figure 2. Close-up photograph of the nudibranch *Gymnodoris nigricolor* attached to dorsal spine of the datehaze goby. Photo by R. Bolland.

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NORTHEAST PACIFIC MACTRIDAE COMPRISE SIX SUPRASPECIFIC TAXA, NONE OF THEM *MACTRA* OR *SPISULA*

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Hinge teeth suggest that recent northeast mactrids should be allocated to six supraspecific taxa: *Tresus, Mactromeris, Mactrotoma, Microtoma, Simomactra,* and *Raeta. Tresus* and *Mactromeris* are cool water mactrids with a long geological history in the north Pacific. The other four are warm water mactrids: *Macrotoma* and *Simomactra* have a longer Pacific basin geological record than *Micromactra* or *Raeta,* but these latter two have a longer Atlantic basin record.

SEASONAL, GEOGRAPHIC AND BATHYMETRIC DISTRIBUTION OF OPISTHOBRANCHS AT BAHIA DE LOS ANGELES, BAJA CALIFORNIA, MEXICO

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Preliminary analysis of over a dozen years of collecting data reveals distinct four-dimensional habitat differences and species assemblages in the subtidal and intertidal regions of Bahía de los Angeles, Baja California, Mexico.

Most of the inner bay shoreline is sandy, but there are a few isolated exceptions.

At Punta Gringa a rocky reef extends 100 meters offshore. At this subtidal area, there are three distinct habitats.

In zone 1, the shallowest region (less than 10 feet), there are numerous small, smoothly-rounded rollable rocks. Species found in this area include *Okenia* sp. nov. and *Trapania* sp. nov.; *Acanthodoris pina* (Marcus & Marcus, 1967), *Tyrinna evelinae* (Marcus, 1958), *Dendrodoris krebsii* (Morch, 1863), *Aeolidiella chromosoma* (Cockerell, in Cockerell & Eliot, 1905), and *Phidiana lascrucensis* Bertsch & Ferreira, 1974.

Zone 2 at Punta Gringa consists of the main rocky reef (10-25 feet deep), with ledges and ridges. The solid rock substrate is densely covered by species of sponges, anemones (especially *Phialoba steinbecki*), and alcyonarians (*Psammogorgia, Eugorgia aurantica, Lophogorgia alba,* etc.). There are seasonal blooms of algae (prominent are *Sargassum, Colpomenia,* and a filamentous green alga), of the anemone *Boloceroides,* and the bryozoan *Zoobotryon.* Opisthobranchs occuring in this region are *Bajaeolis bertschi* Gosliner & Behrens, 1986, and *Polycerella glandulosa* Behrens & Gosliner, 1988 (both seasonal); *Tridachiella diomedea* (Bergh, 1894), *Berthellina engeli* Gardiner, 1936, the coral-feeding *Phestilla lugubris* (Bergh, 1870), and an unnamed genus/species of tritoniid (cryptically camouflaged on an unnamed species of *Epizoanthus*).

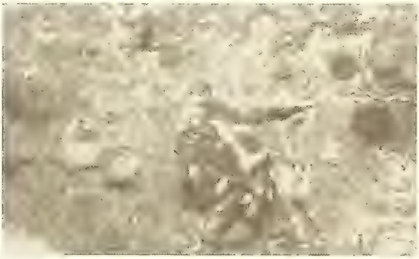

Figure 1. *Okenia* sp., 10 mm in length. Collected 3 m deep, Punta Gringa, Bahía de Los Angeles, Baja California, Mexico, 27 February, 1989, by Hans Bertsch (Photo M 2983, by HB).

The third region at Punta Gringa is the deeper edges of the reef (approximately 25 feet deep), where the reef interfaces with a flat sand habitat. The sponge *Pseudosuberites pseudos* is common here. Nudibranchs encountered in this region are the gorgonian-eating *Histiomena convolvulva* (Lance, 1962) and the hydroid-feeding *Flabellina cynara* (Marcus & Marcus, 1967).

Elsewhere in the bay (away from the inner shoreline) are other faunal assemblages. For instance, on the west side of Isla Cabeza de Caballo, a rock reef is populated only by gymnodorids: the bryozoan-feeding *Tambja eliora* (Marcus & Marcus, 1967) and *Tambja abdere/fusca* Farmer, 1978 (these latter two species are probably synonymous), and the *Tambja*-eating *Roboastra tigris* Farmer, 1978. An unnamed lemon yellow and black splotched species of *Dendrodoris* has been collected only from Isla Coronado and Puerto Don Juan.

Continuing research is in progress to quantify the seasonal and geographic differences in the occurrences of opisthobranch molluscs at Bahía de los Angeles.

THE FAMILY TRIPHORIDAE IN THE INDO-PACIFIC OCEANS: A COMPARISON OF THE SPECIES FROM ACROSS WIDELY EXTENDED RANGES

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On a map of these two oceans, most of the locations from which specimens of Triphoridae have been given to the Los Angeles Museum collection were shown in my talk by arrows.

Geographic variation was illustrated by 3 to 5 specimans of each of the following 10 species:

Metaxia exaltata Powell, 1930, 5 specimens, total distributional range 11,000 miles.

Iniforis ordinate Laseron, 1958, 4 specimens, range 12,000 miles.

Iniforis zonata Laseron, 1958, 4 specimens, range 7,000 miles.

Mastonia rubra Hinds, 1843, 6 specimens from 5 locations, range 12,000 miles.

Mastonia ustulata Hervier, 1897, 4 specimens, range 11,000 miles.

Viriola incisa Pease, 1861, 5 specimens, range 12,000 miles.

Isotriphora bilineata Kosuge, 1962, 4 specimens, range 6,200 miles.

Bouchetriphora pallida Pease, 1871, 4 specimens, range 12,000 miles.

Triphora taeniolata Hervier, 1897, 5 specimens, range 7,000 miles.

Nanaphora albogemmata Laseron, 1958, 3 specimens, range 11,000 miles.

Only the most perfect specimens available were used for this comparison and most are from the Los Angeles museum collection.

DISTRIBUTION OF THE GENUS *MACOMA* (PELECYPODA: TELLINACEA) IN PUGET SOUND, WASHINGTON WITH NOTES ON TAXONOMY

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The purpose of this report is to discuss the distribution of 10 species of *Macoma* in Puget Sound with respect to substrate types, topography and other physical characteristics. A brief discussion is also included to aid in identification of the various species that have been identified in benthic baseline studies in the sound since 1982.

Baseline studies are to establish the existing physical characteristics of an area either proposed or in process of change. The information presented in this paper is a composite of six different baseline studies conducted over a period of eight years. The area of study is the main body of Puget Sound from Everett Harbor to Commencement Bay. The sediments along the rapidly sloping shelf range from course sands and gravels to finer silts and clays in the basins (Word *et al.,* 1984).

Six different studies were used for analysis of *Macoma* distribution ranging from Everett Harbor, WA, to Commencement Bay, Tacoma, WA. The first study is the Homeporting Project in Everett Harbor (hp, 1985). The second study area, the Seahurst Baseline Study covered the area from Point Williams, just south of Blake Island, south to Browns Point with two stations in Quartermaster Harbor (Word *et al.*, 1984). This study also included an intertidal study, ranging from Lincoln Park to Dash Point, and around Vashon Island (Thom *et al.*, (1984). The third study was Alki Predesign in 1985 (Osborn *et al.*, 1985). The last three studies were all conducted in Commencement Bay. These three studies had consecutive samplings of one to two years following the initial studies. The fourth site is City of Tacoma Central Outfall done in 1988 and 1989 (Parametric, 1988b, 1989b). The fifth site was the Simpson Tacoma Kraft Mill Outfall Baseline Study in 1988 and 1989 (Parametrix, 1988c, 1989c). The sixth and most analyzed study was the Asarco Tacoma Smelter Remedial Investigation in 1988, 1989 and the yacht basin in 1990 (Parametrix, 1988a, 1989a).

In all studies, except the intertidal, samples were taken with a modified 0.1 sq. m Van Veen grab. Sediments were seived through 1.0 mm screen boxes, fixed with 10% formalin and sea water, later rescreened, placed in 70% denatured ethyl alcohol and stained for processing. Sediments were sorted to phyla by trained technicians, QC'd and organisms sent to professional taxonomists for identification and enumeration.

In the intertidal study, core samples were collected at each site. Core sizes were 625 sq. cm x 30 cm deep and 23.7 sq. cm x 10 cm deep. Sediments were sieved through 12.5 mm and 1 mm mesh screens, respectively. The former bivalves were frozen and the latter placed in 70% ethanol (Thom *et al.*, 1984).

It should be emphasized that *Macoma* distributions in this paper are based primarily on subtidal data. Overall, the most abundant *Macoma* in Puget Sound is *Macoma carlottensis.* This species is particularly prevalent in areas of industrial activity or in deep water areas where silt collects in basins of mid-channels. *Macoma carlottensis* tends to be a tolerant species with with respect to heavy organics and chemical influences.

Macoma elimata appeared to be the second most tolerant species, and was found generally in the same areas as *M. carlottensis,* but in substantially less numbers. It preferred more calm, silty to fine sand sediments.

Macoma nasuta was found in most studies but not in high numbers. It appeared mostly in calm bay areas rather than more exposed locations. It was also found more in intertidal areas and in larger sizes. This species tended to prefer sediments with more fine sand and silt.

Macoma yoldiformis was found throughout the sound, but tended to prefer more coarse sand, pristine sediments. It was found in deeper areas with more enriched sediments.

Macoma moesta alaskana also tended to prefer more exposed areas, and in fact was non-existent in Everett Harbor. This species didn't appear to have a particular sediment preference but did seem to be in areas of enriched sediment.

Macoma obliqua didn't tend to have a particular preference but it was usually found in reference areas, or generalized in sampling areas. They were found in fine to medium sand in fairly small numbers.

Macoma balthica seemed to have the smallest distribution and least numbers. It appears to have a preference for more sheltered areas in quiet bays. Specimens were found in silt to fine sand.

Macoma inquinata was found subtidally only in Everett Harbor, but did show up at a few locations intertidally.

Macoma secta was not seen at all subtidally but did show up in the Seahurst intertidal study.

Macoma calcarea was seen the least and a question exists as to whether the identification of the species in the Seahurst study is correct. The specimen used for identification is from Budd Inlet which indicates existence of this species in the Puget Sound region. Actual distribution, however, is unclear.

Generally species were found where they would be expected. *Macoma* in general tends to prefer quiet bay areas, with at least a moderate component of silt or sand. This was characteristic of the sites sampled for the six studies. All Commencement studies were in the sheltered area of the bay where currents are low and buildup of finer sediments occurs. This is also true of Everett Harbor.

Certain species appear to be more sensitive to disturbances. *M. moesta alaskana* demonstrates such sensitivity. *M. balthica* appears to be sediment specific as well.

Specific conclusions on distribution cannot be made, however, as populations change from year to year and season to season. In order to verify the trends, yearly studies need to be made at all sites concerned.

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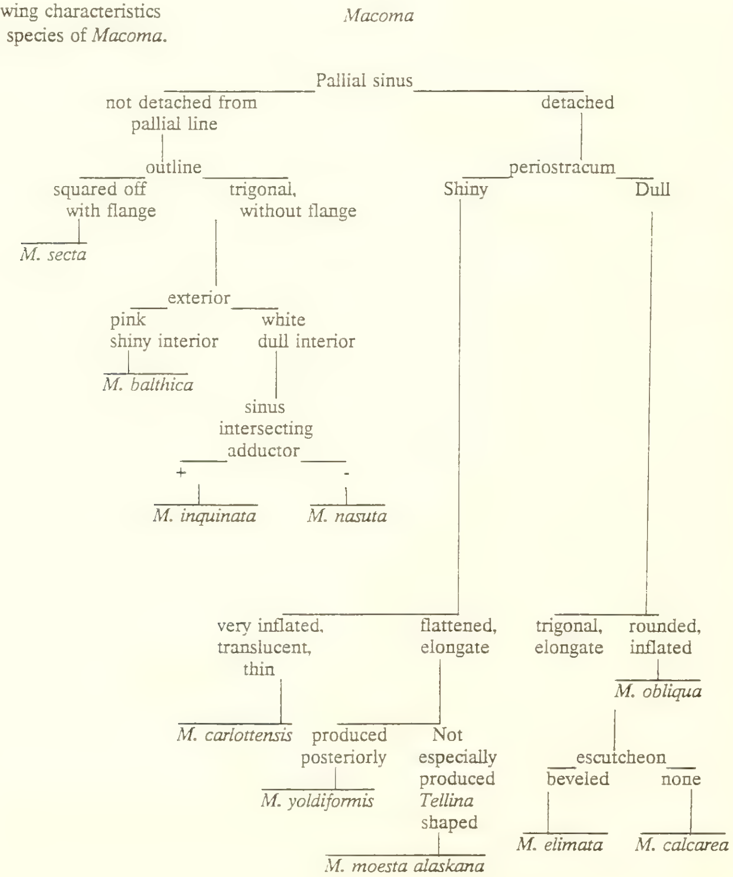
Flow chart showing characteristics unique to each species of *Macoma.*



SMALL BOAT DREDGING WITH RESULTING PANAMIC PROVINCE MOLLUSCAN RANGE EXTENSIONS

Carol Skoglund
3846 E. Highland Avenue
Phoenix, Arizona 85018

A description of dredging with a 14 foot aluminum boat and a small dredge made of angle iron covered with hardware cloth was followed by a report of new range extensions.

Agatrix strongi (Shasky, 1961) was dredged off Danzante Island, Gulf of California, at 200 m. Previous northern limit of the species on the Baja California side of the Gulf of California was Punta Arena, Baja California Sur, Mexico.

Trigonostoma breve (Sowerby, 1832) was dredged in Bahía Carizal, Colima, Mexico, at 20 m. Previous northern limit of the species was Nicaragua.

Dredging off Playas del Coco, Guanacaste, Costa Rica, resulted in 15 range extensions as follows:

Plicatula inezana Durham, 1950. Depth: 31-36m. Previos known range: Gulf of California to southern Mexico

Limaria hemphilli (Hertlein & Strong, 1946). Depth: 9-30m. Previous known range: Monterey, California to Acapulco, Guerrero, Mexico.

Pitar perfragilis Pilsbry & Lowe, 1932. Depth: 24-37 m. Previous known range: Gulf of California, Mexico, to Nicaragua.

Chione purpurissata Dall, 1902. Depth: 9-31m. Previous known range: Gulf of California, Mexico, to Guatemala.

Tellina ochracea Carpenter, 1864. Depth 9-18m. Previous known range: Gulf of California.

Lyonsia californica Conrad, 1837. Depth: 24-37. Previous known range: San Diego, California to Acapulco, Guerrero, Mexico.

Crucibulum concameratum Reeve, 1859. Depth: 9-18. Previous known range: Gulf of California to Acapulco, Guerrero, Mexico.

Metula ellena Olsson, 1972. Depth: 9-24m. Previous known range: Acapulco, Guerrero, Mexico.

Axelella campbelli (Shasky, 1981). Depth: 30-37m. Previous known range: Gulf of California to Gulf of Tehuantec, Mexico.

Calliclava subtilis McLean & Poorman, 1971. Depth: 9-30m. Previous known range: Panama.

Drillia sinuosa McLean & Poorman, 1971. Depth: 9-30m. Previous known range: Islas Galápagos, Ecuador.

Crassispira cortezi Shasky & Campbell, 1964. Depth: 9-30m. Previous known range: Gulf of California.

Acteocina carinata (Carpenter, 1857). Depth: 9-30m. Previous known range: Gulf of California to Mazatlan, Sinaloa, Mexico.

Cylichna fantasma (Baker & Hanna, 1927). Depth: 9-30m. Previous known range: Gulf of California, Mexico.

Cylichnella defuncta Baker & Hanna, 1927. Depth: 9-30m. Previous known range: Gulf of California, Mexico.

A DYNAMIC APPROACH TO MODELING GASTROPOD GROWTH AND SHAPE

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A simplified approach to modeling shell growth which does not describe shells, but rather attempts to mimic growing organisms is presented. Shells are modeled as simple cones. Results from geometric computer modeling offer a basis for interpreting growth rate/shape change correlations in gastropod shells.

ANNUAL BUSINESS MEETING
Western Society of Malacologists
Seattle, Washington
18-22 June 1990

By vote of the membership, the Society is sponsoring the symposium on bivalves at the 1991 joint meeting of the Western Society of Malacologists and the American Malacological Society. The voting members decided (as a one year only, non precedent setting exception) to allocate $2,000 for the symposium in lieu of this year's Student Grant.

Officers of the Western Society of Malacologists, 1990-1991:

President	Paul H. Scott
1st Vice President	David K. Mulliner
2nd Vice President	Kirstie Kaiser
Treasurer	Henry Chaney
Secretary	C. Clif Coney
Immediate Past Presidents	Roland Anderson Hans Bertsch Matthew J. James

STUDENT GRANT, 1990

The Western Society of Malacologists and the Santa Barbara Shell Club combined to give two student grants this year. A major award was presented to Jay C. Schneider of the University of Chicago for his research on the Cardiidae. An additional sum was granted to support the undergraduate research of Troy Clark, at the University of California at Santa Barbara.

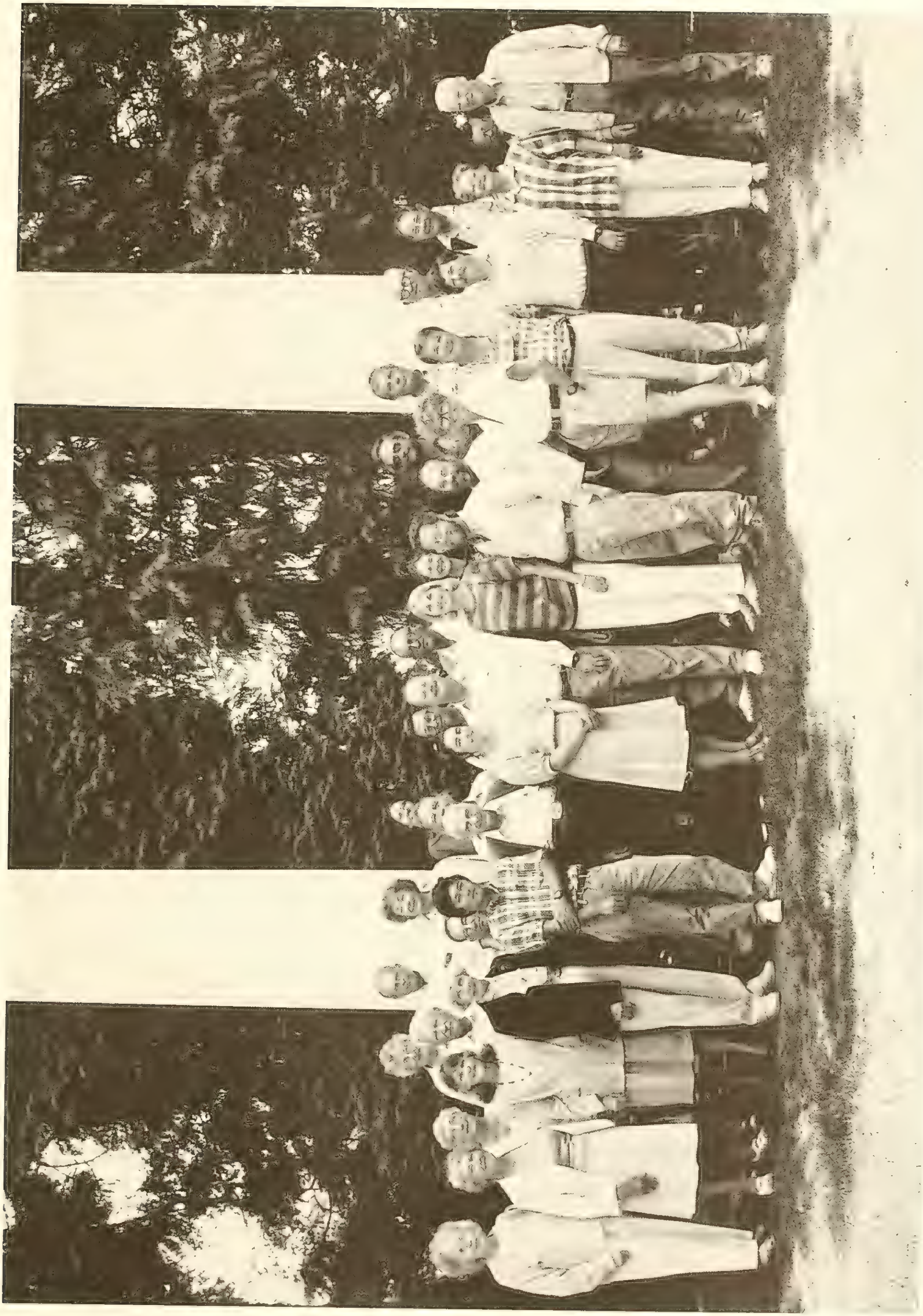
WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1989 - 30 September 1990

INCOME

Membership dues	$2374.00	
Student grant donations (1990)	25.00	
Symposium fund	456.00	
Publication sales and page charges	95.00	
Interest on savings accounts	616.50	
1990 Meeting income	2364.00	
Auction and reprint sales	1151.50	
TOTAL INCOME during period		**$7082.85**

EXPENSES

Annual report	$3346.38	
Memberships and fees	42.00	
Reimbursements to officers	336.14	
Student grant (postage)	61.50	
1990 Meeting expenses	2432.66	
TOTAL EXPENSES during period		**$6218.68**
Net Gain for period		864.17
Beginning balance (1 October 1989)		9783.54
NET WORTH on 1 October 1990		**$10301.10**



ANNOUNCEMENTS OF FUTURE MEETINGS

The **24th Annual Meeting** of the **Western Society of Malacologists** will be a combined joint meeting with the American Malacological Union, to be held 30 June to 5 July 1991, at the Clark Kerr Campus of the University of California, Berkeley.

Three symposia are planned:

MARINE BIVALVE RESEARCH IN THE NEXT CENTURY: A REVIEW OF THE CURRENT STATE OF OUR KNOWLEDGE AND DIRECTIONS FOR THE FUTURE.
Organized by Paul H. Scott, Brian Morton, and Eugene V. Coan.

MOLLUSCAN TAPHONOMY AND PALEOECOLOGY.
Organized by Carole S. Hickman and Michael P. Russell.

MOLLUSCAN BIOGEOGRAPHY OF THE PACIFIC BASIN.
Organized by David R. Lindberg and Geerat J. Vermeij.

In addition to the symposia, contributed papers and poster presentations, scheduled events will include field trips (Molluscan environs of San Francisco Bay, Bodega Head and Bodega Marine Laboratory, Año Nuevo State Reserve, and Napa Valley Wine Country), an outdoor barbecue, a joint WSM/AMU auction, a dessert reception at the Museum of Paleontology, and a 4th of July Banquet in the Great Hall of the Faculty Club. Fossil and Recent mollusc collections in the California Academy of Sciences and the UC Museum of Paleontology will be available to meeting participants.

For more information, please contact Paul H. Scott, President, WSM, Santa Barbara Museum of Natual History, 2559 Puesta del Sol, Santa Barbara, CA 93015, USA. Telephone (805) 682-4711, ext. 319; FAX (805) 569-3170.

The **25th Annual Meeting** of the **Western Society of Malacologists,** celebrating a quarter century of our society's premier contributions to molluscan research, will be held in late June 1992, at Asilomar, California. Appropriately, Mr. David K. Mulliner will be President.

Among the various celebratory events, is a planned symposium on the MALACOFAUNA OF ISLA DE COCO, COSTA RICA.

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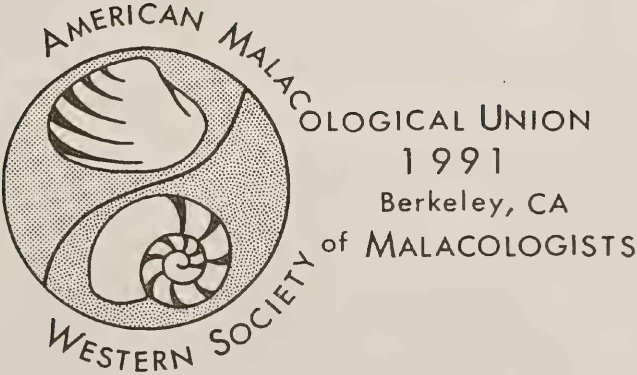
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Paul H. Scott

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The Western Society of Malacologists has issued two **Occasional Papers** – No. 1, "'Sea Shells of the Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; and No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan.

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In Memoriam

Rae Baxter, Red Mountain, Alaska (22 March 1991)

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To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Research Associate, Department of Invertebrate Zoology, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, California 90007 USA.

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23 Allozyme and Morphological Differentiation in the Freshwater Snail *Viviparus georgianus*. MASAYA KATOH

23 An Unusual Instance of Discordant Genetic Markers in the Freshwater Mussel Genus *Pyganodon* (Unionidae: Anodontini). WALTER R. HOEH

24 A Phylogenetic Analysis of the Pulmonate Gastropods and Its Implications for Pulmonate Invasion of Fresh Waters. RICHARD V. LAMB

24 Generic Review of the Aquatic Snail Subfamily Cochliopinae (Gastropoda: Hydrobiidae). ROBERT HERSHLER and FRED G. THOMPSON

24 Phylogenetic Relationships in the Genus *Biomphalaria* (Gastropoda: Planorbidae). SUSAN M. BANDONI, MARGARET MULVEY and ERIC S. LOKER

24 Introduced Ampullariid and Viviparid Amphibious Snails in Hawaii. R. H. COWIE

25 Mystery Fluke in *Melanoides tuberculata* (Gastropoda: Thiaridae) in the San Antonio Zoo, San Antonio, Texas. KARELYN EMILY KNOTT and HAROLD D. MURRAY

25 Looking Up the Wrong End: Anatomical Characters of Freshwater Bivalves (Mollusca: Unionacea). ARTHUR E. BOGAN

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26 The Aplacophora as Progenetic Aculifera. AMELIE H. SCHELTEMA

26 Phylogenetic Systematics of the Recent Subfamilies of Volutidae (Gastropoda: Prosobranchia). M.G. HARASEWYCH

26 Phylogenetic Relationships in the Subfamily Odontocymbiolinae (Gastropoda: Volutidae): Preliminary Results. JOSE H. LEAL

26 Preliminary Ideas Toward a Revision of the Ovulidae (Gastropoda: Cypraeacea). GARY ROSENBERG

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THE EARLIEST BIVALVES AND THEIR ORDOVICIAN DESCENDANTS

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Replicated shell microstructure in a specimen of *Fordilla troyensis* from the Early Cambrian of Greenland confirms a close relationship between *Fordilla* from the North Atlantic region and *Pojetaia* from the Early Cambrian of Australia and China. These genera may be best regarded as stem-group bivalves in that they probably predate the latest common ancestor of living members of the class. Two other bivalved mollusks from the Middle Cambrian (*Tuarangia* and *Pseudomyona*) had D-shaped valves, a single adductor muscle, and shells formed of foliated calcite; they have been interpreted either as early pteriomorphs or as bivalved monoplacophorans. They may, in fact, be larval bivalves. The challenge is to relate these Cambrian taxa to the members of the modern subclasses and orders of the Bivalvia which first appear in Ordovician strata.

EVOLUTIONARY SIGNIFICANCE OF SHELL AND LIGAMENT MICROSTRUCTURE IN THE BIVALVIA

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Shell and ligament microstructure can be misleading with regard to phylogenetic relationships in the Bivalvia unless one's database includes both ancient and modern taxa. Shell and ligament microstructure is commonly convergent at the family and superfamily level among Jurassic - Recent representatives of lineages which had become distinct by late Paleozoic time. Unraveling these convergences suggests that: 1. Some early Nuculanoidea and Solemyoidea were nacreous or at least partially nacreous. 2. The ancestral nuculoid ligament was simple arched or simple planar *sensu* T.R. Waller, and very weakly mineralized or unmineralized. 3. The Arcoida and Pterioida are ancestrally nacreous with a very weakly mineralized or unmineralized and at least superficially duplivincular ligament. 4. The divided fibrous ligament in the Arcidae is not primitive within the Arcoida, but evolved from the united fibrous ligament of the Parallelodontidae. 5. The Triassic arcoid *Pichleria* may be closely related to the Paleozoic cyrtodontids. 6. The Triassic pterioid *Cassianella* differs from most other pterioids but resembles *Pichleria* in having a wholly aragonitic nacroprismatic shell in some species, without calcite in the outer shell layer. 7. The immediate common ancestor of the Dimyidae, Plicatulidae and Ostreidae is probably a nacreous *Lopha*-like species more closely related to the Pterineidae and Malleidae than to the Pseudomonotidae. 8. The Pectinoida is ancestrally nacreous, but most if not all Triassic pectinoid families had already replaced nacre with porcelaneous and/or foliated microstructures.

BIVALVIAN MACROSYSTEM BASED BOTH ON CONCHOLOGY AND ON ANATOMY

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The primary branches of the class are characterized by general structural types of dentition, gills and stomach. They are superorder Nuculiformii (=Protobranchia), Mytiliformii (=Autobranchia), Conocardiiformii (=Septibranchia). The first superorder is divided into orders Nuculiformes and Solemyiformes (each with 2 suborders) on the basis of dentition, and structure of the gills and stomach. The superorder Mytiliformii is divided into eight orders on the basis of dentition (and sometimes presence or absence of anterior dorsal margin), partly the structure of the gills and heart, and the structure of the stomach. These orders are (number of suborders in brackets): Unioniformes (3), Mytiliformes (2), Pectiniformes (2), Pholadomyiformes (3), Hippuritiformes (2), Luciniformes (4), Carditiformes, Cardiiformes (5). The superorder Conocardiiformii is divided into four orders on the basis of shell shape, structure and function of the septum and structure of the stomach. The extinct order Conocardiiformes is included here on the basis of presence of septal muscle impressions. These four orders are: Verticordiiformes (2), Conocardiiformes (3), Poromyiformes, Cuspidariiformes (2 suborders, Dallicordioidei is perhaps an independent order).

THE EVOLUTION OF DEEP-SEA PROTOBRANCH BIVALVES

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The evolution of the deep-sea Protobranchia is considered in relation to their feeding strategies. One of the cornerstones of their success in colonizing abyssal soft sediments lies in their ability to digest extracellularly organic materials in low concentration. The time needed to digest such material contained in a column of sediment is maximized by the possession of a much elongated hindgut, the progression of material within it being controlled by the muscular compression of the bulbous stomach. Elongation of the hindgut has been accompanied by a variety of configurations of its course. These maximize the length of tube that can be accommodated within the space of the visceral mass. It would appear that this has been the major evolutionary concern within the deep-sea protobranchs.

CLADES VS. GRADES IN BIVALVE CLASSIFICATION – SOME EXAMPLES FROM THE TELLINACEA

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Supraspecific classification in the Tellinacea is hindered by inadequate descriptions of many type species, by unsatisfactory diagnoses, and by uncertainties about polarities of many character states. Even the traditional subdivision of Tellinidae into 2 subfamilies is questionable as it seems that lateral teeth have become lost independently in several different clades. Worse, the main criterion by which Scrobiculariidae and Semelidae are separated from Tellinidae, i.e. the presence in the 2 former taxa of an internal resilium seems equally flawed. Five pairs of genera, the first with an external, the other with an external resilium, are examined – *Peronaea / Scrobicularia, Arcopagia / Semele, Moerella / Semelangulus, Pinguitellina / Abranda*, and *Cadella / Semelina*. Except for ligamental differences, the members of each pair are very similar to each other. In particular, the last-named pair share an unusual shell character – the cardinal teeth diverge not from the beak, but from a point in front. It seems more likely that an internal resilium has evolved independently in at least 5 different clades; the alternative, that the resemblance's result from convergence, is less probable. This implies that Scrobiculariidae and Semelidae cannot be satisfactorily segregated from Tellinidae.

TAXONOMY AND GEOGRAPHICAL DISTRIBUTION OF SMOOTH-SHELLED *MYTILUS*

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Smooth-shelled mussels belonging to the genus *Mytilus* can be assigned to one of three distinct evolutionary lineages, *M. edulis* Linnaeus, 1758, *M. galloprovincialis* Lamarck, 1819, and *M. trossulus* Gould, 1850. Individual characteristics of these mussels can vary, often extensively, both within and between populations and are thus of limited taxonomic value. However, these mussels can be effectively discriminated using multivariate analysis of several allozyme and morphometric characters. This genetic and morphological distinctiveness, which is maintained across vast geographical distances despite the occurrence of varying degrees of hybridization and massive potential for larval dispersal, ought to be recognized. Accordingly, therefore, these taxa are best considered as three separate biological species. Hybrid zones are spatially complex with pure, mixed and hybrid populations co-occurring in a patchwork pattern. Laboratory experiments suggest that the apparent temporal stability of the *M. edulis/M. galloprovincialis* hybrid zone in South West England could be maintained, at least partially, through selection against hybrid larvae prior to their recruitment to the established population. All three species occur in northern waters but only *M. edulis* and *M. galloprovincialis* have so far been recorded in the southern hemisphere. *Mytilus edulis* is absent from north Pacific shores, and along the west coast of North America the smooth-shelled mussel populations consist of *M. trossulus* to the north and *M. galloprovincialis* to the south; in central California both species together with their hybrids are present. The origin and evolution of mussels within the genus *Mytilus* are briefly discussed. Future research should concentrate on the biological processes which keep these taxa distinct despite the widespread occurrence of hybridization and introgression.

A NEW APPROACH TO THE STUDY OF BIVALVE EVOLUTION

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Radio-immuno-assay (RIA) measures genetic distance between taxa by measuring how much antibodies made against proteins of one species bind with proteins of another. The resulting immunological distances correlate highly with DNA hybridization results. RIA is unique in that it can extract information from proteins preserved in fossil and recent calcareous matrices. Since most molluscan collections consist predominantly of dry shells, for any studies of their evolution, RIA could be very important. It has been used in evolutionary studies of fossil or recent mammals, reptiles, amphibians, birds, brachiopods, coelenterates, plants, and algae. I am using RIA to study parallel evolution in the Veneridae, and to develop a phylogenetic outline of the family. Taxonomy of the family is currently based on obvious malacological similarities, but preliminary results suggest that such similarities are often the result of parallel evolution. A more accurate classification may need to depend more strongly on anatomical, biomolecular and biogeographical data.

WHAT DO WE KNOW ABOUT CRETACEOUS PACIFIC SLOPE VENERID BIVALVES?

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The family Veneridae evolved from the Arcticidae during the Jurassic and Cretaceous Periods. Studies of fossils suggest that various venerid genera evolved from different arcticids and the family is polyphyletic in the sense that it did not arise from a single arcticid progenitor.

Pacific Slope venerid species have been described by Gabb (1864, 1869) who was both the earliest descriptor and describer of the largest number of species, Whiteaves (1874, 1876, 1879, 1884, 1903), Cooper (1894), Waring (1917), Packard (1922), Anderson and Hanna (1935), Anderson (1938, 1958), Popenoe (1937), and Dailey and Popenoe (1966) (See Appendix for names of species and Figure 1 for geologic ranges). A review of all known Pacific Slope Cretaceous venerids suggests that few have been adequately studied. Many of those described before 1930 were allotted to broad, ill-defined genera and were poorly located stratigraphically and geographically. Stewart (1930) located many of Gabb's type specimens, selected lectotypes, recognized type localities, discussed appropriate generic and family allocations, and made possible subsequent revisions of these species. The first hundred years of work on Cretaceous venerids resulted in a total of 19 recognized described species from Pacific Slope deposits ranging in age from early Albian (approx. 107 Ma) to late Maastrichtian (66.4 Ma). But, as shallow water faunas of some ages have yet to be studied, the possibility of finding more new species and genera is large.

None of the other Pacific Slope venerid genera is likely to be as well represented as is *Calva* Popenoe, 1937, which can be divided into 4 subgenera and 16 species, 9 of which are new (Saul and Popenoe, 1992). Geographic occurrences of two of the subgenera suggest that one is more thermophilic than the other, and the changes in their distributions may reflect broad climatic fluctuations. In addition to *Calva*, another 8 species of venerids, including 3 new genera and 4 new species are currently being described or discussed (Saul, in press), bringing the number of Cretaceous Pacific Slope Cretaceous venerids to 30 species. However, no more than eight species are recognized during any stage (Figure 1). Diversity of Pacific Slope Cretaceous venerids is thus about a third that of modern venerid diversity. Other venerid genera such as "*Tenea*," which ranges from Albian to Maastrichtian but is represented by only one described species, is expected upon further study to comprise several species and provide an increase in the number of Cretaceous species.

Recent West Coast venerids have been grouped into 6 subfamilies in the Treatise on Invertebrate Paleontology (Keen, 1969); additionally, the Panamic fauna includes representatives of 3 others. The subfamilial composition of the Pacific Slope Cretaceous is grossly different from that of the Recent. Instead of the 9 subfamilies of the Recent, there are possibly 4 subfamilies in the Cretaceous. The best represented Cretaceous subfamily is the Pitarinae. Recent pitarines have anterior lateral teeth but no posterior laterals. Three Cretaceous genera with only anterior laterals are present, but two genera, *Calva* Popenoe, 1937, and *Loxo* Dailey and Popenoe, 1966, that bulk large in Pacific Slope Cretaceous faunas, have both anterior and posterior lateral teeth. Only one genus, *Legumen* Conrad, 1858, is assigned to the Tapetinae, and it does not resemble Recent tapetine genera. The Cyclininae is represented by "*Tenea*" *inflata* (Gabb, 1864), which resembles a Recent *Cyclinella* Dall, 1902, except that cardinal tooth 1 is closer to the ventral hinge plate margin, and by *Cyprimeria* Conrad, 1864. *Paraesa* Casey, 1952, has an excavated hinge plate suggestive of the Clementinae. Of the Recent venerids, the best represented group is the Chioninae. Nothing resembling the Chioninae has shown up in Pacific Slope deposits of Cretaceous age.

Casey (1952) demonstrated that the corbiculoid hinge of venerid genera evolved from the arcticoid hinge of arcticid genera. The corbiculoid and arcticoid hinge types must be viewed as grades because transformations of arcticoid hinges into corbiculoid hinges take place in several lineages (Casey, 1952). In the evolution of these hinges the lateral teeth are apparently pleisiomorphic. Evolution of venerids from arcticids involves the loss to some degree of lateral teeth; posterior laterals are dispensed with before anterior laterals. Cretaceous arcticid and venerid familial allotments and venerid subfamilial groupings of the Treatise (Keen, 1969) are in part based on level of hinge development.

As predicted by arcticoid to corbiculoid hinge evolution, the Pitarinae are the common, widespread group of Pacific Slope Cretaceous venerids. *Calva* and *Loxo* retain the posterior laterals of the ancestral Arcticidae. A new genus (Saul, in press) comprising "*Aphrodina*" *arata* and "*Meretrix*" *fragilis* has a grooved 4b, as in *Resatrix* Casey, 1952, but had lost the posterior laterals by Turonian time. The loss of laterals began even earlier in some lineages. The laterals disappear during the ontogeny of *Vectorbis* Casey, 1952, of Aptian age, and *Paraesa* of late Albian age has neither posterior nor anterior laterals. In Pacific Slope "*Tenea*" only a few hinges of Campanian age have been completely exposed to view. They are of early corbiculoid type, whereas Maastrichtian age hinges of typical *Tenea* Conrad, 1870, are of advanced arcticoid type.

Pacific Slope Cretaceous venerids remain underdescribed and several lineages (that of "*Tenea*" comes foremost to mind) still need to be studied. As presently constituted the Veneridae are not strictly monophyletic. Because of the sequential way venerids have evolved from arcticids, the Arcticidae is a paraphyletic family.

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Appendix

Pacific Slope Cretaceous venerids
New taxa of Saul (in press) are listed as bold letters.

probable Veneridae, unknown subfamily

Callista (?) subtrigona Whiteaves, 1876	Albian
Dosinia pertenuis Gabb, 1864	?Turonian

Pitarinae

Calva (*Egelicalva*) *bowersiana* (Cooper, 1894) (Popenoe, 1937)	Late Campanian
= *Cytherea (Caryatis) plana* Sowerby of Whiteaves, 1879	
= *Cucullaea bowersiana* Cooper, 1894	
= *Meretrix nitida* Gabb of Whiteaves, 1903	
= *Chione varians* (Gabb) of Waring, 1917	
= *Meretrix nitida major* Packard, 1922	
= *"Meretrix" coronada* Anderson, 1958	
Calva (*Egelicalva*) *buttensis* Anderson, 1958	Early Campanian
= *Trigonocallista varians* (Gabb) of Taff. Hanna, & Cross, 1940	
= *Trigonocallista buttensis* Anderson, 1958	
Calva (*Microcalva*) *haggarti* Saul & Popenoe, 1992	Late Campanian
= *Cytherea* (*Callista*) *lacinata* Stolizcka of Whiteaves, 1879	
= *Meretrix arata* Gabb of Whiteaves, 1903	
Calva (*Egelicalva*) *crassa* Saul & Popenoe, 1992	Early Maastrichtian
= *Calva "steineyi"* Hertlein MSS of Popenoe, 1954	
= *Trigonocallista major* (Packard) of Anderson, 1958	
= *Calva varians* (Gabb) of Dailey & Popenoe, 1966	
Calva (Calva) heliaca Saul & Popenoe, 1992	Cenomanian
Calva (Calva) campanae Saul & Popenoe, 1992	Late Campanian
Calva (Calva) babtisia Saul & Popenoe, 1992	Late late Maastrichtian
Calva (*Egelicalva*) *byblidis* Saul & Popenoe, 1992	Early - mid Albian
Calva (*Egelicalva*) *spissa* Saul & Popenoe, 1992	Turonian
= *Trigonocallista* cf. *T. varians* (Gabb) of Hall, 1958	
Calva (*Microcalva*) *elderi* Saul & Popenoe, 1992	Coniacian
Calva (*Penecalista*) *marina* Saul & Popenoe, 1992	Late late Campanian - early Maastrichtian
Calva (*Egelicalva*) *nitida* (Gabb, 1864)	Late Albian - Cenomanian
= *Meretrix nitida* Gabb, 1864	
Calva (Calva) peninsularis (Anderson & Hanna, 1935)	Late late Campanian - early Maastrichtian
= *Corbis peninsularis* Anderson & Hanna, 1935	
Calva (Calva) regina Popenoe, 1937	Turonian
= *Trigonacallista regina* (Popenoe) of Anderson, 1958	
Calva (*Egelicalva*) *taffi* (Anderson, 1958)	Coniacian - Santonian
= *Trigonocallista nitida* (Gabb) of Taff, Hanna, & Cross, 1940	
= *Trigonocallista taffi* Anderson, 1958	
Calva (Calva) varians (Gabb, 1864)	Late Maastrichtian
= *Venus (Mercenaria) varians* Gabb, 1864	
= *Aphrodina varians* (Gabb) of Stewart, 1930	
Loxo decore Dailey & Popenoe, 1966	Late Campanian - early Maastrichtian
Loxo n. sp. **N** Saul, in press	Late Maastrichtian
N. gen **B.** *arata* (Gabb, 1864) (Saul, in press)	Turonian
= *Meretrix arata* Gabb, 1864	
= *?Aphrodina arata* (Gabb, 1864) (Popenoe, 1937)	
N. gen. **B.** *fragilis* (Gabb, 1869) (Saul, in press)	Late Maastrichtian
= *Meretrix fragilis* Gabb, 1869	

N. gen. O n. sp. P Saul, in press	Turonian
N. gen. Q n. sp. R Saul, in press	Turonian

Tapetinae ?

Legumen ooides (Gabb, 1864) (Popenoe, 1937)	Santonian - Maastrichtian
= *Tellina ooides* Gabb, 1864	

Clementiinae ?

Paraesa (?) lens (Gabb, 1864) (Saul, in press)	Santonian - early Maastrichtian
= *Meretrix lens* Gabb, 1864	
= *Tellina meekiana* Whiteaves, 1874	
= *Cyprimeria lens* Whiteaves, 1903	
= *Cyprina anthracicola* Whiteaves, 1903	
= *Macrocallista cordata* Waring, 1917	
= *Flaventia lens* (Gabb, 1864) (Stewart, 1930)	
= *Flaventia hornbyensis* Anderson, 1958	
Paraesa n. sp. S. Saul, in press	Late Albian
Paraesa (?) zeta (Popenoe, 1937)	Turonian
= *Flaventia zeta* Popenoe, 1937	

Cyclininae

Cyprimeria moorei Popenoe, 1937	Turonian
"Tenea" inflata (Gabb, 1864) (Popenoe, 1937)	Albian - Maastrichtian
= *Dosinia inflata* Gabb, 1864	
= *Lucina Richardsonii* Whiteaves, 1874	
= *Thetiopsis circularis* Meek & Hayden of Whiteaves, 1879	
= *Clisocolus dubius* (Gabb) of White, 1889	
= *Dosinia milthoidea* Waring, 1917	

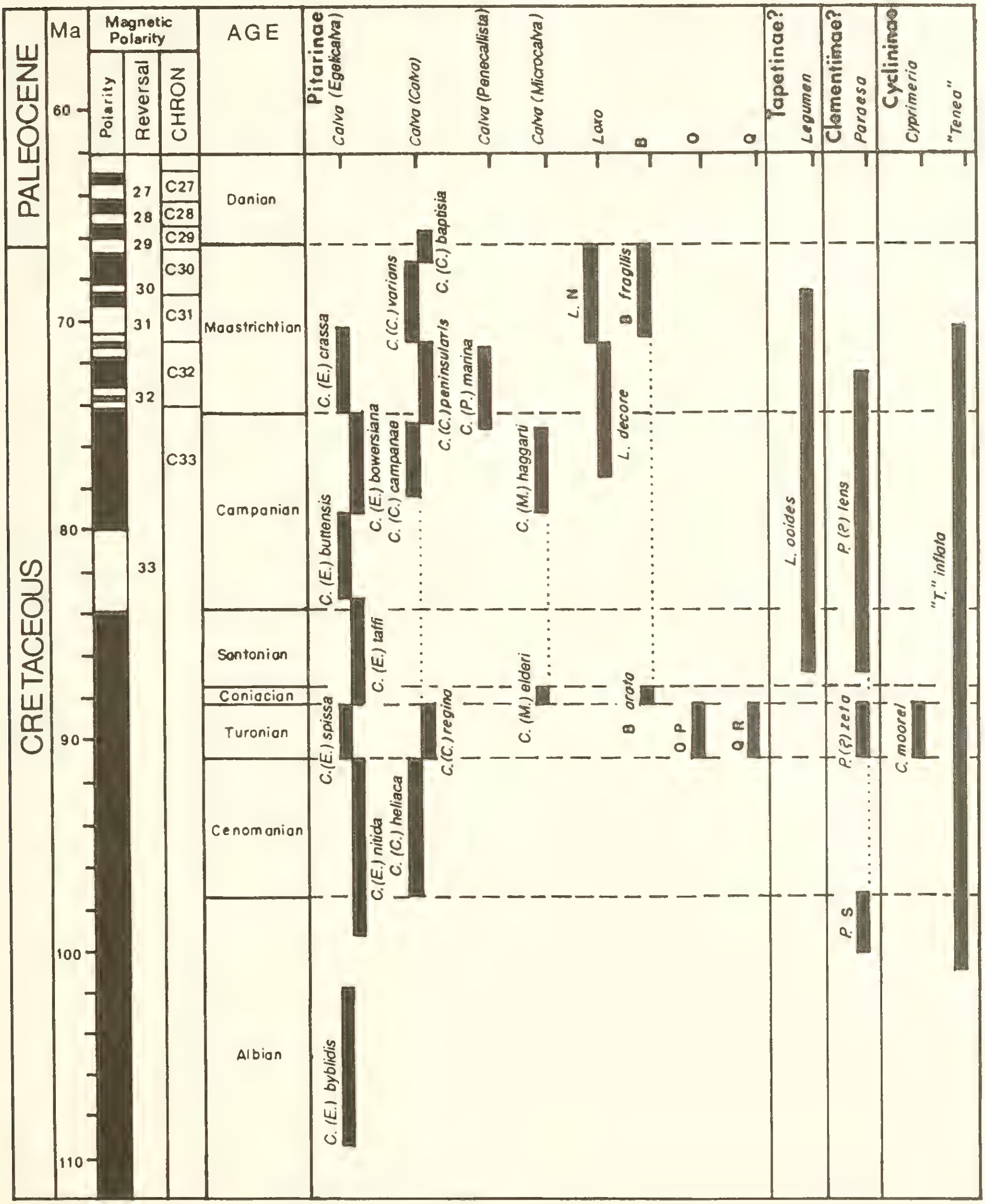
Pacific Slope species described as venerids assigned elsewhere

Eriphyla veatchii (Gabb, 1864) Astartidae	
= *Venus veatchii* Gabb, 1864	Early Campanian
Eriphyla lenticularis Gabb, 1864 Astartidae	
= *Venus lenticularis* Gabb, 1864	Cenomanian or Turonian
Neltia angulata Gabb, 1864 (Saul, 1972) Mactridae	
= *?Chione angulata* Gabb, 1864	early Albian
Etea angulata (Packard, 1922) (Popenoe, 1937) Arcticidae	
= *Meretrix angulata* Packard, 1922	Campanian

Pacific Slope species described as venerids but of unknown affinities

"Cyprina" denmanensis Whiteaves, 1903 may be Mactridae	?Late Campanian
Cyprina occidentalis Whiteaves, 1884	Jurassic
Dosinia? tenuis Meek, 1861 ?Astartidae	Campanian
= *Cyprimeria? tenuis* (Meek, 1861) Meek, 1876	
Meretrix longa Gabb, 1864	?Campanian
"Meretrix" marshana Anderson, 1958 not a venerid	Maastrichtian
"Venus" collinium Anderson, 1938	?Barremian
"Venus" corella Anderson, 1938	?Albian
"Venus" tetrahedra Gabb, 1864	Albian or Cenomanian

Figure 1. Geologic ranges of Pacific Slope venerid species. Bold letters have been substituted for manuscript names of 'in press' species. See appendix for species, authors and synonymies.



CLADISTIC PHYLOGENY OF THE CARDIID BIVALVES

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Previous classifications of cardiids have been based on a small number of key characters, or have been superficially based on shell shape. The phylogeny of Kafanov and Popov was based on 1) morphology of the stomach, and 2) shell microstructure; similar shell shapes evolve independently in different lineages.

A cladistic analysis was undertaken using most recognized fossil and Recent cardiid and tridacnid genera and subgenera. The carditids *Cardita* and *Cyclocardia* are outgroups. Morphology of the entire shell and soft part anatomy are studied, including: labial palps, ctenidia, foot, byssus, siphons, tentacles, stomach, and gut. Cardiid anatomy is very conservative. Most phylogenetic information comes from the complex shell, notably the hinge, ribs, and ornamentation. Cardiid shell microstructure is found to be remarkably uniform.

The Protocardiinae is the sister taxon to the rest of the family. The Cardiinae *sensu* Keen is paraphyletic: *Plagiocardium* is the least derived member of the Clinocardiinae, and *Parvicardium* is the least derived member of the Fraginae, which also includes tridacnids. Keen's Laevicardiinae is polyphyletic and should be abandoned: *Laevicardium* is a protocardiine, *Cerastoderma* belongs with the Lymnocardiinae (the sister taxon of the Fraginae), *Dinocardium* is allied with the cardiine *Vepricardium;* remaining members belong in the Clinocardiinae. The Trachycardiinae is a monophyletic taxon.

THE AUSTRALASIAN PROTOCARDIINAE REVISITED

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The Protocardiinae are the oldest representatives of the family Cardiidae, with a fossil record extending back to the Triassic. This relict group now occurs mostly on the outer shelf and upper continental slope, and the Western Pacific is the area of maximum diversity. Based on an extensive suite of material from the Cenozoic and Recent of the Indo-Pacific, the Australasian species of Protocardiinae are reevaluated in terms of taxonomy and biogeography. Five Recent Australian and one New Zealand species have been recognized and are traditionally allocated to *Nemocardium (s.l.).* Considering its characteristic sculptural pattern and restricted Australian-New Zealand distribution since Cretaceous, I recognize *Pratulum* as a distinctive genus. Reports of its occurrence in tropical locales are the result of misidentification and/or confusion with related genera. Fossil Australian species have also been erroneously referred to *Pratulum,* and the claim that it represents a Tethyan Indo-Pacific element appears unfounded. I recognize two Recent Australian (one undescribed) and one New Zealand species of *Pratulum.* The genera *Microcardium* and *Trifaricardium* are here reported for the first time in Australasia, with one new species each in Australia and New Caledonia. The other Australian species are classified in *Lyrocardium* and *Frigidocardium,* with a single species remaining in *Nemocardium* proper.

MEIOCARDIA OF THE INDO-WESTERN PACIFIC AND THE WESTERN ATLANTIC

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Meiocardia is a very small group of the Glossidae. Fossil species of *Meiocardia* are reported from the Tertiary sediments of Europe and U.S.A., but living species are only known from the Western Pacific and the Western Atlantic. Present classification of the Western Pacific species is confused and it is necessary to review them. *Meiocardia moltkiana* (Gmelin, 1791), the type species of *Meiocardia,* has a higher shell with strong concentric ribs and is possibly a higher form of *M. lamarckii* (Reeve, 1845). The Philippine and Seychelles species has very strong concentric ribs and is referable to *M. sanguineomaculata* (Dunker, 1882), which is *M. moltkiana* of Reeve (1845) and Buelow (1906), not of Gmelin (1791). *Meiocardia lamarckii* of Japanese authors is not the species of Reeve (1845), but is possibly assignable to *M. cumingii* (A. Adams, 1864). There is no confusion of identification of *M. vulgaris* (Reeve, 1845) and *M. tetragona* (A. Adams & Reeve, 1850). Syntypes of the former are stored in the Natural History Museum in London. Descriptions of two new additions to *Meiocardia* species from the Philippine-New Caledonia and Taiwan-Phuket regions are prepared. The Philippine-New Caledonia species with two secondary dorsal ridges has a very close resemblance to *M. agassizii* Dall, 1889, of the Western Atlantic, which also has the secondary dorsal ridges.

PRELIMINARY REVIEW OF HOLOCENE AND PLEISTOCENE NORTHEASTERN PACIFIC *GLYCYMERIS*

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Of the eight species names used for Holocene and Pleistocene northeastern Pacific *Glycymeris*, only two are valid: *G. septentrionalis* (Middendorff. 1849) [Syns. *G. barbarensis* of authors, not of Conrad (1857); *G. corteziana* Dall, 1916; *G. guadalupensis* Strong, 1938; *G. migueliana* Dall, 1916; *G. profunda* (Dall, 1878); *G. subobsoleta* (Carpenter, 1864)] and *G. keenae* Willett, 1943.

The name *Glycymeris barbarensis* has been applied to Pleistocene and modern specimens from southern California over the past 90 years. Recently rediscovered specimens believed to be the primary types at the Academy of Natural Sciences of Philadelphia have been tentatively identified as *G. major* (Stanton, 1896), a Paleocene to Eocene fossil from California.

Glycymeris keenae is extant only at Forrester Island. Alaska. This species is small, with a rounded-trigonal outline and only concentric sculpture. Several lots from Monterey Bay, central California, are considered fossil because of their state of preservation. Fossil mollusks from a late Pleistocene sea-level lowstand are commonly dredged from this area of the California coast, and so these specimens are referred to this lowstand. This species ranges in age from latest Pleistocene to Holocene. *Glycymeris septentrionalis* is a very variable species, as indicated by its list of synonyms. Specimens from a single locality show a narrow range of variability in the shell outline, the size and shape of the hinge, and the thickness of the shell, but over the geographic range of the species all shell features vary considerably. This species ranges geographically from the type locality at Chirikof Island (56°N) in the western Gulf of Alaska southward to Rocas Alijos (25°N), Baja California Sur, Mexico, and has been reported from faunas as old as Miocene.

A TAXONOMIC REVIEW OF THE NORTHEASTERN PACIFIC BIVALVIA: THE UNANSWERED QUESTIONS

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Work in progress on a volume on the bivalves of the northeastern Pacific serves to highlight many unresolved taxonomic problems. It also illustrates the need for much greater international communication and collaboration, and the importance of undertaking work on taxonomic problems on a multi-disciplinary basis.

KEEPING UP TO DATE ON PANAMIC PROVINCE BIVALVE LITERATURE

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Over 170 papers have been written since 1971 that affect Panamic Province bivalve taxonomy and/or distribution. The genus has been changed for 113 species of bivalves. Twenty-three new species have been described. Forty-one species previously known from other parts of the world are now known to occur within the Panamic Province. Twenty-nine other species have been added to the total known fauna. During the same time period, 37 species, which were listed earlier, were deleted.

FUNCTIONAL MORPHOLOGY OF THE STOMACH IN THE BIVALVE *LYONSIA HYALINA* CONRAD, 1831

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Lyonsia hyalina is a small free-living bivalve found in shallow waters of the Northwest Atlantic. Mucus is secreted from specialized mantle glands which act to secure sand grains to the fragile shell. In this study structures used for feeding within the viscera of *Lyonsia hyalina* were examined using micro-dissection and conventional light microscopy. Dissection revealed a complex type 4 stomach characterized especially by a short, simple major typhlosole and a left pouch which receives no ducts from the digestive diverticula. The stomach is suspected to have three particle sorting areas: SA, SA^3, and SA^8. An intact crystalline style was never observed and may have quickly dissolved in every case, since a loose cohesive mass was commonly seen in the stomach and style sac. Histological study revealed various types of ciliated columnar epithelium throughout the gut. The morphology of the epithelium of the style sac and midgut is typical to that described for many bivalves.

THE "YOYO CLAMS" OF FLORIDA, AND A DISCUSSION OF SYSTEMATIC CHARACTERS IN GALEOMMATIDAE

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Five new species of the galeommatid genus *Divariscintilla* have been discovered in eastern Florida. All five are commensal with a single species of mantis shrimp on shallow-water sand flats, and are known to co-occur within the extensive burrows of the shrimp. The only other known member of the genus is the type species, *D. maoria* Powell, also an inhabitant of mantis shrimp burrows, in New Zealand. Anatomical description of the five Floridian species has included an interesting suite of complex characters, presumably reflective of the clams specialized habitat. Several of these ("hanging" foot morphology, "flower-like organs") are also known from species assigned to other genera, currently placed in other families. With present taxonomy of the superfamily still largely dependent on hinge and ctenidial characters, the status of these interesting specializations has come into question.

A cladistic analysis (using Hennig86) has been conducted on anatomically well-known species in the family Galeommatidae (including *Galeomma*, *Scintilla, Ephippodonta*, *Divariscintilla, Phlyctaenachlamys, Vasconiella*, and others), plus selected members of other galeommatoidean genera. Characters analyzed involved the shell, mantle, foot, ctenidia, digestive system, reproduction, and ecology. Results to be discussed will examine the relative systematic value of various characters, comment on generic and familial definitions, and indicate critical species in need of closer scrutiny.

EVOLUTION OF THE BIVALVE GENUS *LASAEA*

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Present results indicate that sexual members of the marine bivalve genus *Lasaea* with planktotrophic larval development are much less successful than their direct-developing, asexual congeners. I have constructed a set of alternate hypotheses to explain how this biogeographic paradox may have evolved. To test these hypotheses I am reconstructing intrageneric evolutionary and biogeographic relationships using mitochondrial DNA genotypes. I am presently sequencing a mitochondrial gene, Cytochrome Oxidase III, from a variety of *Lasaea* populations. The aims are to characterize phylogenetic relationships in this genus on a global scale and to look for evidence of transoceanic rafting by direct developers.

SEASONAL VARIATIONS IN BROOD SIZE AND LARVAL SIZE OF *LASAEA* cf. *NIPPONICA* (BIVALVIA) IN HONG KONG

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Monthly samples of *Septifer virgatus* were examined for *Lasaea* cf. *nipponica*. Each individual obtained was measured to the nearest 0.1 mm and dissected. Individuals brooding shelled larvae were isolated, broods counted and larval shell lengths measured to the nearest micron.

In Hong Kong, *Lasaea* cf. *nipponica* produces two broods each year, in spring (May) and autumn (October to December). Spring parents brood large numbers ($\cong$ $120.\text{parent}^{-1}$) of longer ($\cong$320-330 μm) larvae; autumn parents brood fewer ($< 50.\text{parent}^{-1}$) numbers of smaller ($=$ 300-320 μm) larvae.

Ó Foighil (1986) has suggested for the similarly brooding *Lasaea subviridis* that prodissoconch morphology is environmentally regulated such that brooded larvae of intertidal parents have a Prodissoconch II morphology whereas individuals brooded by submerged parents only develop a Prodissoconch I morphology.

This study of *Lasaea* cf. *nipponica* suggests that variations in brood size and larval size, and thus morphology, result from seasonal differences in environmental factors, possibly acting upon the larvae but, more likely, upon the parents and thereby indirectly upon the brood. Brood size larval size are thus likely to vary not just seasonally, but across the spectrum of populations encompassed by the species range.

SETTLEMENT AND METAMORPHOSIS OF MARINE BIVALVES

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Methods for the chemical induction of settlement and metamorphosis of bivalve larvae would be useful both for aquaculture and for the study of development. Early studies on the environmental cues responsible for spatfall suggested that settlement of *Crassostrea virginica* could be induced by copper carried into estuaries by freshwater. Later studies on American and European oysters provided evidence that metamorphosis was stimulated by factors which could be extracted from the tissues of adult bivalves. Recent work has suggested that substances secreted by bacteria may be involved in the step-wise stimulation of settlement behavior and metamorphic processes.

Settlement-behavior of pacific oysters and *Ctenoides scabra* is stimulated by ammonia generated by the titration of ammonium chloride with sodium hydroxide. Supernatants from a strain of bacterium containing similar levels of ammonia can also stimulate settlement behavior. Epinephrine bitartrate solutions which induced metamorphosis when they were titrated with sodium hydroxide also generated ammonia.

It has been suggested that once settlement behavior of Pacific oyster larvae has been initiated by ammonia secreted by bacteria living on the sediment interface the larvae are exposed to other contact-dependent and soluble cues. The induction of metamorphosis can be stimulated by L-DOPA which may be secreted by bacteria.

PRISMATIC SHELL FORMATION IN TEMPORARILY OPEN EXTRAPALLIAL SPACES: EXPLICABLE?

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Many aspects of molluscan biomineralization, such as control of polymorphic type and form of microstructures, yet remain unexplained. A comparison of formation of prismatic shell in two species of bivalves is presented that suggests, as indicated by one current hypothesis, that soluble organic matrix precedes and regulates the type and form of biocrystals. In *Mytilus edulis* Linne prisms develop at the shell margin in an extrapallial space continuously closed to seawater by the emerging periostracal sheet, the mantle margin remaining in place. In *Crassostrea virginica* (Gmelin), however, margins of mantle lobes frequently withdraw into the mantle cavity, exposing prismatic surfaces to seawater. Prism-secreting cells, even though they could be precisely repositioned over growing prisms, probably do not control the form of these prisms; rather, once nucleated in the soluble matrix, each biocrystal with its accompanying matrix probably mediates mineralization and shape of that prism and subsequent prisms in the prismatic column. Thus, after the secreting epithelium is reestablished over prisms, bathing them in extrapallial fluid, growth is resumed without deformation.

BLUE MUSSEL (*MYTILUS EDULIS*) MORTALITY IN BRITISH COLUMBIA: COMPARISON OF PACIFIC AND TRANSPLANTED ATLANTIC MUSSELS

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Normal longevity of British Columbian blue mussels (*Mytilus edulis*) is about one year, with mortality suggested to be a natural senescence. In 1989, Nova Scotian mussels were brought to British Columbia so that comparative survival between Atlantic and Pacific mussels strains could be investigated. Nova Scotian mussel mortality was low in 1989, and F_1 progeny remain alive in 1991. Biochemical analysis of constituent seasonal energy reserve suggested that substantial physiological differences may exist between the Nova Scotian and British Columbian strains. However, there were also differences between British Columbian strains in different years, indicating that more rigorous comparative monitoring is required to document possible strain differences. After spawning, Nova Scotian mussels began to show an increase in soma weight whereas British Columbian mussels continued to show a decrease in soma weight, with death the apparent ultimate result.

PARALYTIC SHELLFISH POISONING TOXINS AS A CHEMICAL DEFENSE IN THE BUTTER CLAM (*SAXIDOMUS GIGANTEUS*)

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Studies investigating the relative resistance of bivalve species to saxitoxin (STX), and the influence of STX contaminated clams on the feeding behaviors of three important vertebrate predators (sea gulls, fish and sea otters), strongly suggest that butter clams (*Saxidomus giganteus*) are able to utilize dinoflagellate toxins as a highly effective deterrent to predation. Action potential recordings indicate that the butter clam and the Washington clam (*Saxidomus nuttalli)* are 10-100 times more resistant to STX than four co-occurring bivalves (*Mya arenaria, M. truncata, Tresus capax, Protothaca staminea)*. In feeding experiments with naive, free-ranging, wild glaucous-winged gulls *(Larus glaucescens)*, toxic butter clams were regurgitated in < 15 min., and non-toxic butter clams were never regurgitated. Gulls previously conditioned with toxic S. *giganteus* refused to eat either toxic or non-toxic butter clams but would accept other bivalve prey. Gulls foraging at a chronically toxic site, took significantly fewer butter clams than at a non-toxic site. Stagehorn sculpins *(Leptocottus armatus)* also developed an aversion to toxic butter clams, but unlike sea gulls, were able to distinguish between toxic and non-toxic individuals. It is concluded that 1) neuronal resistance to STX has pre-adapted the butter clam to sequester paralytic shellfish toxin (PST), 2) siphon cropping by fish is the most likely mechanism to have driven the evolution of PST as a chemical defense in butter clams, and 3) once acquired, the ability to retain these highly lethal neurotoxins can be an effective defense against a wide range of vertebrate predators.

THE ROLE OF BIVALVE REEFS AND BEDS IN COASTAL ECOSYSTEMS

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In shallow coastal waters and estuaries, dense bivalve assemblages, primarily oyster reefs, mussel beds and cockle beds, form major structural features. Studies over the past 10-years indicate these bivalve systems also play a major role in the functioning of coastal ecosystems. they remove large quantities of suspended particulate material including inorganic sediments, phytoplankton, organic detritus and zooplankton from the surrounding water column. Dissolved substances like amino acids, sugars, heavy metals, etc. are also actively removed. Some of these materials are utilized as food yielding metabolic waste such as ammonium and orthophosphate. Because these systems enriched the surrounding sediments, other dissolved substances are released as a result of benthic bacterial decomposition.

Based on their filtration capabilities bivalve reefs and beds have been touted as eutrophic control mechanisms, increasing sedimentation, and limiting phytoplankton productivity. Their high material release rates have been speculated to increase phytoplankton production and nutrient recycling. Recent manipulation experiments on whole ecosystems support some of these claims, but point to water residence time as a major contributing factor.

A RE-EVALUATION OF THE ROLE OF *MYTILUS CALIFORNIANUS* IN A ROCKY INTERTIDAL COMMUNITY

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In the rocky intertidal community of western North America mechanisms which prevent the mussel *Mytilus californianus* from occupying all available space, such as preferential predation, wave shear, and battering by logs, have long been considered responsible for maintaining the diversity of this community. However, an examination of mussel beds in California and Oregon revealed that virtually all species competitively inferior to *M. californianus* live on the shells of this mussel. Consequently, these species can co-exist with *M. californianus* even where it occupies all rock surfaces. This suggests that diversity is maintained not by mechanisms which remove mussels from the substrate, but because mussels supply their competitive inferiors with a refuge from competition.

In addition, an examination of the population dynamics of species common on both substrates showed that while growth and reproductive status were not affected by the type of substrate, both recruitment rates and survivorship were higher on mussels than on rock. Therefore, all else being equal, it is more beneficial to live on mussels than on rock.

NATICID GASTROPOD PREDATION ON CORBULID BIVALVES: PHYSICAL AND BIOLOGICAL CONTROLS

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Naticid gastropod predation on corbulid bivalves is said to be anomalous in a number of ways. The preferred hypothesis for anomalous predation is the presence of distinct conchiolin (organic) layers within corbulid bivalves. This explanation, however, is incompatible with the mechanics of shell penetration in drilling gastropods. In addition, the presence of conchiolin layers appears to be characteristic of corbulids, although anomalous predation is not. Because anomalous predation is not universal in or limited to corbulid prey, less inclusive hypotheses are needed. This study documents the occurrence of anomalous predation in several corbulid species as a means to formulate alternative hypotheses. I tested for prey-size selectivity, borehole-site selectivity, and differences in proportions of bored, incompletely-bored, and multiply-bored valves. Predation is site- and size-selective in most species, and there are significant differences in proportions of bored valves between species, environments, and regions, but not over time. Differences in proportions of incompletely and multiply-bored valves between species, regions, and over time did not yield significant results. Possible explanations for most cases of anomalous predation include small sample size, variable prey-shell thickness, and environment factors. Conchiolin layers may have some effect on naticid predation, but are not the only cause of anomalous patterns.

CRYPTIC PROPEAMUSSIIDS AND OTHER BIVALVES FROM A SUBMARINE CAVE OF OKINAWA, SOUTH JAPAN

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A cryptic molluscan fauna, including *Neritopsis radula*, was discovered from a totally dark submarine cave of Ie-jima Island, Okinawa. This cave is a nearly horizontal tunnel (ca. 30 m long) open to the fore-reef slope with an entrance about 20 m below sea level. The wall of the inner part is also inhabited by *Cosa* sp., *Dacrydium* sp., *Parvamussium* sp. and *Carditella* n. sp. Numerous dead shells of about 30 bivalves (mostly new species) were found from calcareous mud on the cave floor. They include Arcidae (2 spp.), Philobryidae (4 spp.), Mytilidae (2 spp.), Propeamussiidae (6 spp.), and Limidae (4 spp.). Nucinellidae, lucinid, carditid, montacutid, crassatellid, kelliellid, hiatellid and cuspidariid species were also found. This bivalve fauna shows such unusual features as: 1) abundant occurrence of *Huxleyia*, *Cosa*, *Dacrydium*, *Parvamussium*, *Divarilima*, *Kelliella* and *Halonympha*, the distribution of which had been almost restricted to deep-waters, 2) very small adult size of each species (length commonly less than 4 mm), 3) persistent provinculum until adult stage in most pteriomorphian species, suggesting paedomorphosis, 4) large (often hat-shaped) prodissoconch I in most species, indicating non-planktotrophic development and K-selection in reproductive strategy. Though the origin of this fauna has yet to be studied, a low level of predation pressure in the lightless and poorly nutritious conditions like deep-sea bottom seems to have permitted the survival of such archaic and anachronistic bivalves.

PATTERNS OF DISTRIBUTION OF OSTREOID BIVALVES ALONG THE WESTERN COASTS OF AUSTRALIA

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The ostreoid fauna of western Australia is dominated by species of Indo-West Pacific regional affinity.

The distributional patterns of these species, and of those of members of the overlapping southern Australian fauna, appear to reflect the geological history of the continent and its waters, and the present climatic regimes, current systems and available habitat types.

It is inferred that the temporal variability of species' range limits is related to that of the south-flowing Leeuwin Current and of its inshore counter-current. The sparse data on biotic factors involved in such relationships are reviewed.

TEMPORAL CHANGES IN THE ABUNDANCE OF THE CLAM *MACOMA BALTHICA* ON AN INTERTIDAL MUDFLAT IN PORT VALDEZ, ALASKA

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The bivalve *Macoma balthica* is the dominant large infaunal species at Dayville Flats at the head of Port Valdez, Prince William Sound. The distribution of this clam correlates with lateral variation in lithofacies, from low abundance values in the gravelly-sandy beds in the western end of the flats to highest values in the muddier eastern end. The bivalve occurs in its greatest numbers in muddy substrates in the upper and middle intertidal zones in the eastern section of the flat. Time-series samples, initiated in September, 1989, demonstrate reduced abundance of *M. balthica* as compared with abundance values recorded in an earlier study in 1974-1977. The reason for the decline is being examined in the context of changes in substrate and relative changes in freshwater input on the flat subsequent to construction (in 1974) of a road, along the upper shore of Dayville Flats.

SIZE FREQUENCY DISTRIBUTION IN A DEAD BIVALVE ASSEMBLAGE AND THE LIVING SOURCE POPULATION IN HAWAII

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A series of catastrophic southerly storms eradicated extensive beds of *Pinna muricata* on the leeward side of Oahu, Hawaii. These vast beds constituted an important ecological environment for numerous mollusks and other invertebrates. A study was undertaken to compare size frequency distributions of both the living source popula-

tions and dead assemblages of bivalve mollusks. Samples were dredged in different areas, depths, and environments in Mamala Bay, Oahu, Hawaii before, during, and after the series of storms.

The bivalves studied were: Cardiidae, *Nemocardium thaanumi;* Condylocardiidae, *Carditella hawaiensis*; Lucinidae, *Ctena bella*; Semelidae, *Ervilia bisculpta* and *E. sandwichensis*; Tellinidae, *Elliptotellina euglypta*, *Tellina oahuana* and *Tellina robusta* .

BIOGEOGRAPHIC PATTERNS OF WEST AFRICAN BIVALVES

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In the course of preparation of a comprehensive identification guide of the bivalves of tropical west Africa (427 species treated, ca. 10,000 lots examined, of which 5000 were collected during extensive field work), I found the distributions of the species to be essentially coincident with the major hydrographic features of the west African shelf:

- northern zone of permanent upwelling, from Morocco to the Sahara
- northern zone of seasonal upwelling, from Cape Blanc to Guinea
- tropical zone, from southern Guinea to Gabon
- southern zone of seasonal upwelling, from Gabon to northern Angola
- southern zone of permanent upwelling, from southern Angola to Namibia

A rather high number of species show a disjunct distribution: these occur either in both areas of permanent upwelling, or in both areas of seasonal upwelling. Vicarianist vs. dispersalist interpretations of such patterns are discussed.

MODERN DEATH ASSEMBLAGES AS A TAPHONOMIC TOOL: EVIDENCE FROM SAN NICOLAS ISLAND, CALIFORNIA

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As every student of paleontology learns, fossils are but remaining threads of the once luxuriant tapestry of life. Quantifying the "death decay and disintegration" of living assemblages should aid in reconstructing the ecological patterns of extinct faunas, for the death assemblage is the raw material of the fossil record.

I compared four subtidal death assemblages from two habitats, with four adjacent fossil assemblages on San Nicolas Island, California. All fossil assemblages were sampled from the second emergent marine terrace that is correlated with substage 5e of the marine oxygen isotope record (~120,000 years ago). The death assemblages represent two distinct communities that are found in sandy beach, and rocky shore, environments. Death assemblages were found accumulating throughout the rocky shore habitat, whereas sandy bottom death assemblages were only found in localized sediment traps adjacent to sandstone benches or boulders. There were 64 species recovered from the fossil assemblages, 68 from the death assemblages, and 39 species were common to both. A comparison between the Pleistocene fossil assemblages and modern death assemblages reveals that habitat or substratum type can be inferred from relative abundance measures of the species present.

PLEISTOCENE MARINE TERRACE ASSEMBLAGES: ARE THERE MODERN ANALOGS?

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The interglacial Pleistocene molluscan faunas are similar to the living fauna. There are few extinct species and fossil species associations tend to include species that live together today. The chief compositional differences result from range changes, at least 33% of the species having retreated from parts of their previous ranges, but otherwise their depositional environments are chiefly consistent with their present habitats. These similarities between fossil and living assemblages invite taphonomic interpretations on uniformitarian grounds, which can work well when depositional sites are carefully selected. However, many terrace assemblages are in basal deposits that rest upon an erosional terrace platform, for which modern analogs are chiefly found beneath the Recent sediment veneer overlying transgressive erosional surfaces; modern shell accumulations on this veneer have few Pleistocene analogs. Comparative preservation potentials favor the Pleistocene assemblages and this may account in part for the unexpected level of completeness of the Pleistocene terrace record.

FROM BLACK SHALES TO SEEPS: RECOGNIZING HABITATS OF CHEMOSYMBIOTIC BIVALVES FROM THE FOSSIL RECORD

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Modern chemosymbiotic bivalves include solemyids and some modiolids, vesicomyids, lucinids and thyasirids. These bivalves occupy a variety of habitats typically characterized by relatively high organic content. In the geologic record, related fossil bivalves are preserved in several types of paleoenvironments that were likely conducive to chemosynthetic adaptation. These fossils are associated with: 1) pillow basalts and sulfide minerals (hydrothermal vents); 2) *in situ* masses of microbial carbonates (cold seeps); 3) laminated to partially bioturbated black shales (stagnant basins); 4) marine mammal bones (microenvironments where bivalves existed on decaying organic matter); and 5) strata deposited in certain nearshore settings (marine grass banks). Not every occurrence of these fossil bivalves is restricted to one of the above paleoecologic associations. Nonetheless, such associations may have utility for increased understanding of the nature of possible chemosymbioses in now-extinct bivalves. For example, a chemosymbiotic life habit has been postulated for members of the Mesozoic Inoceramidae that are found in laminated black shales. However, for at least one example where fossil cold seep carbonates are found in black shales (Tepee Buttes of the Pierre Shale, Upper Cretaceous, Colorado), lucinids predominate in the "core" seep carbonates whereas the less abundant inoceramids are generally restricted to the shaley seep margins. If black shale inoceramids had the same type of bacterial chemosymbiosis as do lucinids, they would be expected to be abundant in the carbonates. Inoceramid scarcity in these deposits, however, implies that their trophic strategy was of a different sort.

RELATIONSHIPS BETWEEN DRILLING PREDATORS AND PREY IN AN EARLY PLEISTOCENE MOLLUSCAN ASSEMBLAGE FROM FIJI

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Gastropods are often ecologically important predators, and those that drill the shells of their prey leave a quantifiable record of prey-predator interactions. Analysis of this record facilitates reconstruction of the trophic structure of fossil communities, a major goal of paleoecology. Assessment of the occurrence and types of boreholes in 2,596 shells of 360 molluscan species from early Pleistocene assemblages from Fiji indicated differential susceptibility to attack among species. Among gastropods, 61% of families, 54% of genera, 50% of species, and 26% of individuals were drilled. The drilling predators were naticids (20 species) and muricids (5 species). Almost all boreholes were complete, suggesting generally successful predation. The most abundant families in the assemblage are the Nassariidae, Turridae, Olividae and Naticidae; the Turridae, Costellariidae, Cerithiidae and Mitridae were most susceptible to drilling (>40% of individuals drilled). In contrast, only 10% of all bivalves in the sample were drilled. We also consider the importance of drilling and peeling predation as mortality factors, their relationship to prey shell size, form and sculpture, and comparisons with a nearby similar Recent community.

THE NATICID GASTROPOD PREDATOR-PREY SYSTEM: DYNAMICS AND EVOLUTION AS PRESERVED IN THE FOSSIL RECORD

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Extant naticid gastropods choose prey non-randomly in accordance with an energy-maximization model. Previous work indicated that naticid predator-prey dynamics were well established by the Miocene; cost-benefit analysis successfully predicted prey choice of Chesapeake Group naticids, and selectivity of Frey size and drillhole site occurred for most prey taxa. Key bivalve prey responded to naticid predation by increasing shell thickness, a strategy that successfully deterred naticid predation; however, a coevolutionary response by the predators could not be demonstrated.

Ongoing work examines the history of the naticid predator-prey system to determine if escalation occurred during the Cretaceous and Paleogene as previously predicted. Work to date reveals no clear trend of escalation. Cretaceous predation levels (8-19% for bivalves) are greater than those for earliest Paleocene samples (3%). Later Paleocene and middle Eocene samples have high predation levels (30%), while predation in the upper Eocene Moodys Branch averages only 10%. Certain taxa are consistently heavily drilled through the Cretaceous and Paleogene; these include lucinids, corbulids, arcoids, and turritellids. No clear trends of escalation in behavioral stereotypy are apparent.

THE PALEOECOLOGY OF THE CHEMICALLY BORING BIVALVE GENUS *LITHOPHAGA*

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The chemical-boring bivalve *Lithophaga* is a significant bio-eroder of coral reefs, but its fossil record is poorly understood. The mytilid genus originated in the Carboniferous. By the Triassic, the genus had evolved from a nestler to a chemical borer, coinciding with the rise of scleractinian corals. Lithophagids are now common around the world at low latitudes. Triassic morphologies are remarkably similar to recent ones. The major differences between lithophagids arise with changes in mode of life, particularly, adaptation to living versus non-living substrates. A study of Eocene lithophagids from Florida has revealed that this fossil species developed the ability to inhabit living coral, not just non-living substrates. This ability has been lost in modern Atlantic species, but occurs in certain Pacific species. Live-coral boring either evolved separately in Florida Eocene and in modern Pacific lithophagids, or was spread throughout the Tethyan seaway by larval transport.

A ROLE FOR TAPHONOMY IN AN EVOLUTIONARY PALEOECOLOGY OF MOLLUSKS: AN EXAMPLE FROM THE FLORIDA PLIO-PLEISTOCENE

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Taphonomic analysis can serve at least two roles in providing a basis for an understanding of the ecological context of evolutionary change: 1) at a small scale, it provides information on the nature of the preserved fossil record, allowing for estimates of time and habitat averaging and information loss; 2) by determining how densely fossiliferous deposits form, specifically the relative roles of biological productivity and biostratinomic processes, it can assist in the recognition of high-productivity environments. Productivity may be of considerable evolutionary importance in controlling patterns of origination and extinction.

Plio-Pleistocene deposits of southern Florida include densely shelly sands that may contain as many as 1200 species of mollusks. This time interval spans a period of major evolutionary and biogeographic change in the Caribbean basin and Gulf of Mexico and Florida's mollusks appear to reflect these changes. Highest diversity correlates with periods of apparently high productivity, possibly associated with upwelling. The late Pliocene western Atlantic regional mass extinction, documented by Stanley, may be related not only to temperature change but also to collapse of productivity in the area, possibly associated with closure of the Panamanian isthmus.

PALEOECOLOGY OF LOWER ALBIAN RUDIST REEFS FROM THE ALISITOS FORMATION, BAJA CALIFORNIA, MEXICO

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Mid-Cretaceous bioherms of rudistid bivalves (Hippuritacea) occur in the predominantly volcaniclastic Alisitos Formation in localities from Punta China to the Vizcaino Peninsula. The Alisitos consists of strata related to a marine arc formed during the eastward subduction of an ocean plate beneath the southwestern margin of North America. These bioherms formed along a very narrow carbonate bank at varying distances from the volcanic arc with the northern localities being more distal and the southern localities more proximal to the arc. The structure and composition of the Alisitos bioherms are most similar to those of the Antillean islands.

Individual bioherms are generally tabular and discontinuous and range from less than 1 m to 10's of meters in thickness. The bioherms are autochthonous / parautochthonous, representing reef and back reef lagoonal depositional environments and vary in diversity between bioherms. The rudist fauna consists of *Caprinuloidea*, *Agriopleura*, *?Caprinula*, *Toucasia*, and *Monopleura.* In a number of bioherms these genera colonized hermatypic coral horizons and eventually excluded the corals. Reef bioherms become dominated by *Caprinuloidea.* Bioherm termination have been related to 2 main factors: volcaniclastic events and oceanographic events.

Results from this study of Alisito's bioherms indicates faunal associations not previously known from other Gulf Coast or Caribbean mid-Cretaceous rudistid bioherms. Although these occurrences represent some of the northernmost rudist paleocommunites of the mid-Cretaceous, these bioherms show normal rudist diversity for the Albian. Future work on systematics may yield important biogeographic information as the bioherms contain unidentified rudist species from a period in which rudists were rapidly radiating throughout the world.

FINE SCALE DIVERSITY PATTERNS IN FRESH-WATER MOLLUSCAN FAUNAS – A TOOL FOR ASSESSING MASS EXTINCTIONS

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The end Cretaceous extinctions have attracted considerable attention in the last decade. Evidence exists for a catastrophic physical event closely associated with the Cretaceous-Tertiary (K-T) boundary. However, determination of a causal linkage between physical events, such as bolide impacts, and extinctions is not a trivial exercise. The disturbance of modern communities is typically associated with declines in ecological diversity. Such declines are reflected in both the total number of species (Richness measures) and the proportional abundance of species (Evenness measures). Fossil fresh-water molluscan communities have lower diversities and occur across fewer rock types than fossil marine communities. These characteristics allow diversity to be calculated from fresh-water molluscan assemblages with smaller sample sizes and with a reduced taphonomic noise as compared to marine assemblages. I present here evidence that declines in measures of the proportional abundance of fresh-water molluscan species sampled from individual stratigraphic horizons can be observed as one works up-section towards an extinction event. This pattern of a gradual decline in diversity appears in the Pliocene extinction of an endemic fauna from an African rift lake in the Edward-Albert basin. In contrast, no such diversity decline appears in the fresh-water molluscan fauna of the latest Cretaceous Hell Creek formation in Montana. Most studies of diversity at extinction events have used species ranges and richness to measure diversity. Such range-based data are subject to considerable sampling problems. The examination of proportional abundance of species in samples from individual horizons is immune to many of the sampling problems inherent in range-based data.

ENVIRONMENTALLY-CORRELATED INTRASPECIFIC VARIATION IN *PRUNUM CONIFORMIS* FROM THE NEOGENE OF THE DOMINICAN REPUBLIC

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Adult size and overall shell morphology are commonly used to recognize species of marginellid gastropods. We analyzed shell form in three fossil marginellid species from the Neogene of the Dominican Republic: *Prunum coniformis, P. latissima* and *P. maoensis*. The three species are found in separate geographic regions and characteristically different paleoenvironments. All three share discrete shell characters, but vary in shell size and shape. Samples of very small *P. coniformis* occur in shallow (<10-20m), probably brackish deposits with sandy substrates. Stout, thick-shelled samples of *P. maoensis* and *P. latissima* occur exclusively in high-energy, nearshore, sandy deposits, with frequent pebbles. Deeper marine deposits (>20 m) contain abundant large *P. coniformis*. Morphological variation among species is continuous. We can detect no temporal pattern in the variation. The variation among these fossil species is strikingly similar to that found within single modern species in this genus. The continuous nature of variation among these three fossil species, the association of different morphologies with different paleoenvironments, and the similarity to variation that occurs within individual modern species, indicates that "*P. latissima*" and "*P. maoensis*" were probably high-energy forms of *P. coniformis*. The extent to which this environmentally-correlated variation was genetically versus ecophenotypically controlled is unknown. This example highlights the importance of paleoenvironmental information to species-level interpretations in the fossil record.

SHAPE, DRAG AND POWER IN AMMONOID SWIMMING

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Drag measurements were used to calculate drag coefficients and the power required for swimming at a variety of sizes and velocities in a series of ammonoid shells of variable lateral compression. The results indicate that the shell shape that confers optimal swimming efficiency is highly dependent on the Reynolds number of operation. Laterally compressed forms, such as oxycones, long thought to be the most efficient swimmers are only more efficient at high Reynolds numbers. At lower Reynolds numbers, likely to be typical of ammonoids of modest size swimming at moderate velocities, less compressed forms will have the advantage of lower drag and power requirements. Thus optimal shell form depends on size and swimming behavior. Swimming velocity should increase with increasing size. Reynolds number is a function of both velocity and size and should increase by three orders of magnitude during the ontogeny of the average ammonoid. Therefore, if ammonoids are adapted for efficient swimming from hatching onwards, their shell shape should become more laterally compressed through ontogeny. Examination of data from the literature suggests that this is the case. Ammonoids hatch at a millimeter in size and are nearly spherical in shape. Once they reach one centimeter in size they are more compressed; width of the whorl is often less than half of the radius of the coil. Nautiloids hatch at a much larger size than ammonoids. Hydrodynamic influences on the smaller juveniles of ammonoids may account for differences in coiling parameters and differences in the evolutionary tempo of the two groups.

NASSARIID GASTROPODS AS DESTRUCTIVE AGENTS IN MARINE FISH TAPHONOMY

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The voracious scavenging behavior of nassariid gastropods is well documented, but the direct physical and taphonomic effects of their feeding on carcasses is not well known. Feeding studies of *Nassarius moestus* (Hinds, 1844) on the intertidal mud flats near San Felipe, Baja California, Mexico, show that they are primary destructive agents to fish carcasses, and provide clues in understanding the taphonomy of marine fishes in nearshore and intertidal environments. Nassariid gastropods affect fish taphonomy through skeletal disarticulation, exposure of skeletal elements to pre-depositional erosion, prevention of whole-body transport and deposition, and through differential dispersal of skeletal elements The influence of nassariid gastropods on fish taphonomy is probably temporally and geographically extensive, since both bony fishes and nassariid gastropods co-occur circumglobally throughout the Cenozoic and in Recent environments. This study also reveals information about the feeding behavior and ecology of *N. moestus*.

THE INFLUENCE OF BEHAVIOR AND SHELL FORM ON THE TAPHONOMY OF STROMBID GASTROPODS

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Strombid gastropods exhibit several behaviors that are unusual among mollusks, most notably their tendency to be gregarious and the frequency with which they bury themselves, particularly as juveniles. The gregarious behavior of most strombid species means that fossil aggregations of these gastropods may represent biological rather than physical accumulations. Living juveniles and adults sometimes congregate separately, so that even size sorting may have a biological component. Most strombid species exhibit characteristic burial behaviors, where individuals, particularly juveniles, spend considerable amounts of time buried in the substrate. This behavior discourages the growth of epibionts and/or boring organisms. The position and abundance of epibionts and boring organisms holds considerable information about the taphonomic history of the individual shell and the deposit as a whole.

Strombids are also unusual among gastropods in that shell growth is determinate: adults of most species are characterized by a thickened, flaring lip, which is lacking in juveniles. Flume experiments demonstrate that adult and juvenile shells of *Strombus floridanus* exhibit characteristically different hydrodynamic behavior. Adult shells generally become oriented with their coiling axis roughly normal to a current, with the relatively shallow slope of the flared lip directed upstream, while juvenile shells more commonly orient with the apex of the shell downstream. Strombids should have a tendency to be found aperture-down in current-deposited strata, unless they were buried quickly while infaunal (i.e. in lip-up position).

INTERPRETING THE SEPARATE TAPHONOMIC FATES OF TURBINID GASTROPOD SHELLS AND OPERCULA IN FOSSIL MOLLUSK ASSEMBLAGES

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Because of the marked difference in size and shape of turbinid shells and opercula, the two skeletal elements are easily separated by taphonomic processes involving transport. In addition, they are differentially susceptible to diagenetic alteration. Their separate taphonomic fates enhance rather than detract from the quality of the gastropod fossil record. Samples from 87 Neogene localities in the northern Dominican Republic contain abundant shells and/or opercula of turbinid gastropod species. Opercula are more abundant than shells at most localities, and while the majority of shells show moderate to considerable breakage, opercula are intact and well preserved. Seven distinct opercular morphologies are present in 130 lots containing a total of approximately 1500 opercula. Initial observations suggest that opercula can provide better estimates of population size structure than shells and that estimates based on shells alone will be skewed toward smaller sizes than estimates based on opercula. Results of analyses from 25 localities where shells and opercula were recovered from bulk samples demonstrate the feasibility of species matching and the feasibility of determining shell size accurately from operculum size. Analysis of a locality preserving both shells and opercula of two species of *Turbo* illustrates the method of analyzing separate taphonomic fates and confirms the prediction that opercula provide a better estimate than shells of population structure. Supported by grants from the Swiss National Science foundation and the Committee on Research, University of California, Berkeley.

MARINE MOLLUSKS OF THE URVINA BAY UPLIFT, GALAPAGOS ISLANDS

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In 1954, the floor of Urvina Bay, Isabela Island in the Galapagos was thrust more than 6 meters above sea level, exposing several square kilometers of its marine community. Animal remains indicate the uplift occurred rapidly and that most of the water percolated through the porous lava. The rapid uplift and drainage preserved the integrity of the community in an invertebrate Pompei, providing an opportunity to examine subtidal marine mollusks associated with corals, basalt and sand usually found at depths of 10 m.

Molluscan assemblages from living and eroded corals, basalt boulders and cobble, and sand channels were analyzed for species composition and diversity. Species diversity is greater in eroded coral heads bored by sea urchins and *Lithophaga* than on undamaged coral heads, and greater beneath coral heads, in basalt cobble and in sand channels than on rubble *Pocillopora* 'islands.' A unique assemblage consists of a swarm of coralliophilids apparently stranded at the tideline when the uplift occurred.

Species composition on the uplift is compared with known Galapagos species lists.

ORIGIN AND INTERCHANGE OF COLD-ADAPTED NORTH PACIFIC MOLLUSCAN FAUNAS

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There are at least three sources for the cold-water faunas that evolved in the North Pacific beginning in the late Eocene. These are the Indo-West-Pacific (or Tethyan) tropics, the American tropics, and the cool southern hemisphere. With the present state of knowledge it is difficult to assign rankings to these sources. but evidence is mounting that the southern hemisphere is the locus of origin of many North Pacific lineages. Throughout the Cenozoic, there has been extensive interchange between the biotas of the western and eastern North Pacific. This interchange tended to be symmetrical during much of the Paleogene, but after the middle Miocene easterly movement markedly outweighed westwardly invasions. I argue that patterns of oceanic circulation are not responsible for this pattern of interchange. Instead, the extent and pattern of invasion seem to be dictated by the magnitude of prior extinction. Northeastern Pacific molluscan faunas suffered greater impoverishment than did those of the northwestern Pacific during the later intervals of the Neogene, and have received more immigrant taxa.

TECTONIC SETTING OF THE NORTH PACIFIC MOLLUSCAN FAUNA

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The tectonic setting in which the North Pacific molluscan fauna developed was a complex array of accretionary, rotational, extensional, and translational movements on an active continental margin. Relative motion between oceanic plates and the North American plate throughout Cenozoic time appears to have been oblique to lateral in direction and from 5 to 10 cm/yr in speed. After multiple pre-Tertiary accretions, Cenozoic tectonism followed separate paths north and south of the Klamath-Siskiyou block. In Paleogene time, rift-erupted tholeiitic basalts preceded oceanward shifting of the trench and marine regression coupled with clock-wise rotation to the north, while to the south, depositional systems developed on a margin produced by pre-Tertiary right-lateral displacement along the "proto-San Andreas" zone, with a weakly developed trench seaward. Acidic vulcanism and marine transgression began to the north in Refugian time, while to the south deposition of shallow marine biogenic shales and prograding non-marine strata occurred without active subduction. The consumption of the Farallon plate resulted in its breakup beginning about 30 m.y. ago, as its generating spreading center was overcome by the North American plate, initiating the translational motion of the San Andreas zone. Throughout Neogene time, the northward propagation of this zone has continued to the Klamath-Siskiyou block, while north of the block continued subduction has resulted in the 40 m.y. old Cascade magmatic arc.

LATE CENOZOIC PALEOCEANOGRAPHY OF THE NORTH PACIFIC OCEAN

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Ever since the start of the Cretaceous, at least, the North Pacific Ocean has been dominated by a central gyre with equatorial and northern currents and eastern and western boundary currents. Major changes in tectonic and oceanographic patterns have not effected it. Thus, the North Pacific Ocean has not had biological interchange with other oceans, except through the Bering Straits. All interchange has been through migration with or against prevailing currents.

The intensity of oceanographic processes in the North Pacific has changed markedly at various times in the Cenozoic. The oceanographic history of the North Pacific Ocean, like the rest of the world's oceans, is intimately linked to the tectonic and oceanographic isolation of Antarctica near the end of the Oligocene. The circum-Antarctic current developed, restricting the efficiency of meridional heat transport, and cold, Antarctic bottom water formed and invaded all ocean basins. Oceanic circulation and upwelling intensity increased through the Neogene, as glacial conditions expanded on Antarctica and ice shelves formed. Throughout the Neogene, the North Pacific experienced eutrophication around its margins and increased isolation in the central gyre. In the east and north, the faunas developed chiefly through in situ evolution because the southerly, cool, eutrophic eastern boundary current served as a barrier to migration from the south, and the cool waters of the northwestern Pacific prevented migration from the west.

LATE CENOZOIC EVOLUTION AND DEVELOPMENT OF THE NORTH PACIFIC MOLLUSCAN FAUNA

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The molluscan fauna of the high-latitude North Pacific changed dramatically during the late Cenozoic. Faunal changes occurred in response to both worldwide and regional warming and cooling trends, as well as to paleogeographic and tectonic events.

The main worldwide climatic events were warm peaks in the early middle Miocene, late Miocene, and Pliocene. These introduced relatively warm-water taxa to northern latitudes. The main cooling event was the onset of northern hemisphere glaciation at the end of the Pliocene and continuing to the modern day.

Tectonic plate movements in southern Alaska caused uplift of coastal mountains, which led to glaciation in the Gulf of Alaska starting in the earliest middle Miocene (ca. 15 Ma). This regional glaciation began at the peak of worldwide Neogene climatic warming. Northward incursions of warm-water mollusks into this cold-water region were El Niño-like events that aid in dating the relatively endemic northern cold-water faunas.

The opening of Bering Strait during the Pliocene (ca 34 Ma) produced the only direct connection between the Arctic and Pacific Oceans since the Middle Cretaceous (Albian), about 105 million years ago. This opening left a distinct faunal signal, because it introduced a large number of Pacific species into the Arctic and a few Arctic species into the Pacific. The North Pacific molluscan fauna has remained essentially the same following the opening of Bering Strait and the subsequent onset of northern hemisphere glaciation.

FAUNAL HISTORY, BIOGEOGRAPHIC PATTERNS AND DIVERSITY IN THE MARINE FAUNA OF THE CENTRAL PACIFIC

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The history of the marine biota of the islands of the central Pacific has two phases: that of the Cretaceous and that of the Tertiary. The Cretaceous Pacific fauna included cosmopolitan Tethyan elements of now extinct corals, rudists, ammonites and belemnites. It was replaced by the Indo-Pacific biota which can be traced to the ancient seaway connecting the Mediterranean and Indo-Pacific from Triassic to Miocene time across what is now the Middle East and Pakistan. Its present center of diversity is in the Indo-Malayan archipelago. Indo-Pacific reef corals in the Hawaiian-Emperor chain appeared in the Oligocene; marine mollusks such as cowries occur contemporaneously in the Miocene of Indonesia, on Guam, Okinawa and Enewetak. Patterns of distribution among the islands are determined by habitat, degree of isolation, and oceanographic events. The last named have ecological implications resulting in, for example, episodes of extinction and recolonization. These factors in turn affect diversity and perhaps account in part for low rates of endemism compared with the terrestrial biota of Pacific islands.

PLEISTOCENE EVOLUTION OF THE NORTH PACIFIC MOLLUSCAN FAUNA

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During the Pleistocene epoch the molluscan fauna of the North Pacific Ocean was subject to numerous physical perturbations associated with the expansion and contraction of the polar ice sheets. Changing temperature regimes and sea level during this time provided almost ideal theoretical conditions for speciation and extinction. However, little of either appears to have occurred. Instead, range shifts, vicariance events, and immigration appear to have been the prominent features of evolution of the North Pacific molluscan fauna. Range shifts along the California coast have been extremely well-documented, and many Pleistocene fossil assemblages are characteristically referred to as either "cold" or "warm" water deposits. Conspicuous vicariance events center around the division of once continuous distributions into cognate taxa in the northeastern and northwestern Pacific Oceans. Immigration occurred from both South America as well as from the North Atlantic Ocean. In both cases however, emigration from the North Pacific is substantially stronger than immigration into it.

MARINE MOLLUSKS OF ROCAS ALIJOS

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The Alijos Expedition of October 1990 was the first to collect mollusks from Rocas Alijos, an isolated remnant of a once larger volcanic island. Rocas Alijos is 185 nautical miles west of Bahía Magdalena, Baja California Sur, from which it is separated by deep water. 165 species of mollusks were collected from intertidal to sublittoral depths by divers and by grab samples. At least six species are endemic new species and five others are shared only with Isla Guadalupe, a similarly isolated island to the north. The fauna is a mixture of Californian and Panamic elements. The affinity of the gastropod fauna is predominantly Californian and that of the bivalve fauna is primarily Panamic. Many Californian species have their southernmost records at Rocas Alijos. No Indo-Pacific faunal elements are known.

NORTH PACIFIC APLACOPHORA

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Aplacophoran mollusks have been collected in the North Pacific from 20 m to hadal depths over 7,000 m, and from the sublittoral of the nutrient-rich east Pacific coast to the abyss beneath the oligotrophic North Pacific gyre. Aplacophora occur at all hydrothermal vents and also upon guyots. Some species are apparently stenotopic, but others live in physically stressed environments. A few species are very widely distributed, but most insofar as known have restricted geographic ranges. Although the total number of species in the North Pacific is small, less than 70 published species, the group persists in all continental shelf and deep-sea environments.

BIOGEOGRAPHY AND TAXON COMPOSITION OF NORTHERN PACIFIC POLYPLACOPHORA

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About one fifth of the more than 800 chiton species worldwide inhabit the warm temperate to subpolar northern Pacific. This study uses newly developed software for automated global mapping and distributional tallies, combined with a current database of worldwide nominal chiton taxa. The northern Pacific chiton fauna is examined with respect to its taxonomic composition, diversity relative to global chiton distributions, reported trans-Pacific distributions, boreal affinities of northern Pacific and Atlantic faunas, and species range limits relative to bathymetric distributions. Supraspecific taxonomic diversity is only moderate, but some taxa are speciose and largely restricted to the northern Pacific. Chitons may show more restricted representation than other molluscan groups because all chitons have nonfeeding larvae that are able to assume a benthic lifestyle within about a week. Reports of wide species ranges are exceptional, often based on unconfirmed reports or questionable synonymies, although some rafting of juveniles and small adults almost certainly occurs.

VICARIANCE RELATIONSHIPS OF THE NORTH PACIFIC OPISTHOBRANCH GASTROPODS

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The opisthobranch mollusk fauna of the North Pacific consists of several distinct components: temperate western Pacific fauna, temperate eastern Pacific fauna, Panamic tropical eastern Pacific fauna and Indo-Pacific fauna. There are endemic components to all of these faunas. The species level and generic phylogeny of most opisthobranch taxa is poorly known. Nevertheless, examining the sister group relationships for taxa where some phylogenetic information is available sheds light on their biogeography. All evidence suggests that each of these faunas has historical relationships to several different geographical regions and that the origins of the present faunas are extremely complex.

PACIFIC OPISTHOBRANCH ZOOGEOGRAPHY: BIODIVERSITY AND ENDEMISM

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Although much alpha-level taxonomy remains to be described throughout the Pacific basin, our knowledge of opisthobranch natural history reveals some distinct zoogeographic trends.

This presentation summarized patterns of species' distributions in various regions of the northern and tropical eastern Pacific, examining different provincial levels of biodiversity and endemism.

It also described differences in the presence of higher-level taxa and variation in the proportionate representation of species with different feeding (prey) preferences.

DEVELOPMENT OF THE LAND MOLLUSK FAUNA OF THE NORTHEAST PACIFIC RIM

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Land mollusk faunal "physiognomies" along the northeast Pacific rim have changed since the early Tertiary. Early middle Eocene land snail fossils from the Santiago Formation, San Diego County, California, have shell height (h) and diameter (d) relationships differing from any found in the Recent land mollusk fauna of California or other northern hemisphere faunas. Similar h and d values are found in the Recent Helicostylinae of the Philippine Islands and Papuininae of northern Australasia. Both Helicostylinae and Papuininae represent endemic radiations on island groups in wet tropical forest. The Santiago Formation fossils may represent such a radiation, and suggest climatic and isolational settings similar to the present-day Philippines.

THE NORTH PACIFIC CEPHALOPODS, ESPECIALLY THE GONATIDAE

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Shell-bearing mollusks of the north Pacific demonstrate unusual biogeographic patterns which merit further study (Vermeij, 1989; Vermeij *et al.*, 1990). In an attempt to discover whether the biogeography of north Pacific cephalopods was consistent with that known from other mollusks, I surveyed the known fauna. Our current knowledge of the north Pacific octopods provides an inadequate basis for biogeographic study and the few species of either sepioids or myopsid squids in the area restrict biogeographic analysis to oegopsid squids. Patterns in the geographic distributions of these open ocean squids in the north Pacific are defined here.

The north Pacific is unique in that a single oegopsid family, the Gonatidae, dominates the squid fauna; over 99% of squids captured in the Bering Sea are gonatids (Kubodera and Jefferts, 1984). The Gonatidae are monophyletic; synapomorphies include the arrangement of the armature of all arms in four, rather than two, rows and the development of hooks on the medial rows of the Arms I-III. Preliminary results suggest that one of the three genera, *Gonatopsis* Sasaki, 1920, is paraphyletic. The diagnostic character of this genus, the absence of tentacles, is inadequate to define a monophyletic group. The systematic position of specimens assigned to *Gonatopsis* must be critically reevaluated.

To address phylogenetic patterns in gonatid radiation, I am undertaking a cladistic analysis of the family which will be published at a later date. Preliminary analysis indicates that the family radiated in the north Pacific (16 species are described from that area) and immigrated into the southern Hemisphere (one recognized species) and the north Atlantic (two species). This pattern is consistent with an early movement into the southern hemisphere and a single Pliocene immigration into the North Atlantic followed by speciation *in situ*, as suggested by Nesis (1973).

Some distributional patterns are evident and appear to be independent of phylogeny. First, species with the most northerly distributions reach the largest body sizes. Second, species which Kubodera and Jefferts (1984) consider to spawn in association with the continental slope have significantly larger geographic ranges (across the Pacific) than do species thought to spawn on the ocean floor.

However, species thought to spawn in association with the continental slope are, in general, those with more northerly distributions; these species have the largest body sizes, and perhaps longest life spans. An interaction of body size, life span, uniparous reproduction and the topography of the north Pacific ocean floor may influence dispersal potential and so contribute to the observed pattern of biogeographic distribution.

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ELECTROPHORETIC AND ANATOMICAL DIFFERENCES IN *LAVIGERIA:* DIVERGENCE IN AN AFRICAN RIFT LAKE ENDEMIC GASTROPOD

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Although the gastropods of Lake Tanganyika provide one of the best examples of the spectacular endemic radiations that characterize some rift lakes, their evolutionary relationships are poorly known. To understand the mechanisms of lacustrine speciation, I am investigating the relationships between morphs in the genus *Lavigeria* (Thiaridae). This genus is extremely diverse both morphologically and genetically. Electrophoretic data supports the distinction of many of the morphs into separate species. Morphologically similar animals from widely separated areas share unique alleles. Sympatric snails of different morphologies are not related in most cases. However, I found examples of both morphological convergence (genetic differences between populations exceed morphological differences) and morphological divergence without genetic separation. Consequently, the genus *Lavigeria* may contain about twelve species, not the currently described two.

Because anatomy is the traditional taxonomic tool for fresh water gastropods, I analyzed 28 characters, both qualitatively and statistically, to look for species differences. I found a unique gland in the foot at the base of the female's ciliated groove in the deep water species. No other size-independent variable assorted with shell morphological differences. In the case of *Lavigeria*. divergence of genetic and shell morphometric characters is not coupled with anatomical changes.

ALLOZYME AND MORPHOLOGICAL DIFFERENTIATION IN THE FRESHWATER SNAIL *VIVIPARUS GEORGIANUS*

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I studied allozyme and morphological variation in the brooding freshwater snail [*Viviparus georgianus* (Lea)], which is variable in shell morphology among populations, in the southeastern United States. Eleven studied populations were clustered into three genetically isolated allopatric species characterized by at least six diagnostic loci among them out of the 42 loci studied. These allopatric species were eastern populations, western populations, and a middle population at Lake Talquin. Nei's standard genetic distances among the species were large (0.23-0.58) but the within-species distances were small (0.00-0.08). Moreover, genetic distances between the species at Lake Talquin and the other two species were larger than genetic distances between eastern and western species. The western species was more differentiated than the eastern species. Wright's F_{st} of the western and eastern species among populations were 0.67 and 0.36, respectively. Most of the genetic differentiation was due to differences among populations within drainage systems, rather than to differences among systems. The western species should be identified as *Viviparus goodrichi* Archer, which was originally described as a subspecies. Shell morphology measurements will be analyzed by principal component analysis and be compared with genetic data to examine whether the three species and genetically distinguishable populations within species are morphologically distinguishable.

AN UNUSUAL INSTANCE OF DISCORDANT GENETIC MARKERS IN THE FRESHWATER MUSSEL GENUS *PYGANODON* (UNIONIDAE: ANODONTINI)

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The degree of correlation between mitochondrial DNA (mtDNA) phylogeny and organismic phylogeny is of great importance to evolutionary biologists using mtDNA phylogeny as an estimator of organismic phylogeny. Investigation of biological systems that exhibit discordance between mtDNA and nuclear DNA-based characteristics should offer insight as to the factors responsible for the observed discordance. Multiple studies are necessary to assess the generality of the assumption that mtDNA phylogeny and organismic phylogeny are highly correlated. When observed, the discordance between mtDNA patterns and nuclear-encoded characteristics is usually accounted for by hypothesizing: 1) introgressive hybridization, 2) stochastic sorting out of ancestral mtDNA polymorphisms, or 3) mtDNA rate heterogeneity. This study reports recent work on an unusual discordance between allozymic and mtDNA markers in the freshwater mussels *Pyganodon cataracta* and *P. fragilis*. Two conditions, 1) knowledge of the taxonomic and phylogenetic distribution of the mtDNA markers, and 2) a hypothesis of evolutionary relationships for the pertinent taxa (based on nuclear-encoded characteristics), permit discrimination among the alternative hypotheses.

A PHYLOGENETIC ANALYSIS OF THE PULMONATE GASTROPODS AND ITS IMPLICATIONS FOR PULMONATE INVASION OF FRESH WATERS

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That freshwater basommatophorans had a terrestrial ancestor is a commonly proposed and long-held hypothesis of pulmonate evolution. The alternative hypothesis is that pulmonates invaded fresh waters directly from marine environments. To test these hypotheses, I conducted a phylogenetic analysis of 18 taxa (14 families of basommatophorans, 3 of systellommatophorans, and Stylommatophora) using 84 anatomical, conchological, and life history characters polarized against a hypothetical ancestor. The single most parsimonious tree formed by HENNIG 86 had a length of 198 and a ci of 0.56. The most parsimonious interpretation of changes in habitat is that pulmonates invaded freshwater once directly from the ocean and invaded land at least 3 times. All terrestrial invasions happened within a clade composed of Ellobioida, Trimusculidae, Systellommatophora, and Stylommatophora, which is the sister taxon to the freshwater basommatophorans.

GENERIC REVIEW OF THE AQUATIC SNAIL SUBFAMILY COCHLIOPINAE (GASTROPODA: HYDROBIIDAE)

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The Cochliopinae (= Littoridininae of authors) is a large (31 genera and over 270 species), predominantly New World subfamily of aquatic prosobranchs found in diverse nonmarine waters. Shell and anatomical study of at least one species in each genus has been completed by us and is the basis for this generic review. Results are discussed, with emphasis on clarifying nomenclature, assessing phylogenetic relationships among the genera, and a preliminary examination of zoogeographic patterns.

PHYLOGENETIC RELATIONSHIPS IN THE GENUS *BIOMPHALARIA* (GASTROPODA: PLANORBIDAE)

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Freshwater snails in the genus *Biomphalaria* transmit *Schistosoma mansoni* in Africa and the neotropics. Systematic relationships among the species remain poorly known and most studies to date have emphasized regional faunas. Twenty-five populations representing seven neotropical and four African species were compared using starch gel electrophoresis. Twenty-five enzyme loci were scored. A phylogenetic analysis was performed on the electrophoretic characters. Sixty equally parsimonious trees were obtained, each with a consistency index of 75.9%. Most of the 60 trees represented rearrangements of the populations of only 3 species. There were only 6 arrangements of the remaining 8 species. In all of the trees obtained the four African species formed a monophyletic group but the neotropical species did not. When either African or neotropical species were analyzed alone, larger numbers of trees were obtained, indicating that further comparisons of the species from both hemispheres will be of considerable utility.

INTRODUCED AMPULLARIID AND VIVIPARID AMPHIBIOUS SNAILS IN HAWAII

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At least six species of the prosobranch families Ampullariidae (one *Pila* sp. and four *Pomacea* spp.) and Viviparidae (one *Cipangopaludina* sp.) have been introduced to Hawaii. These snails are amphibious, breathing with gills when underwater but using the modified mantle cavity as a lung when out of water or when using the inhalant siphon as a snorkel. They can withstand long periods out of the water. Viviparids bear their young live; ampullariids lay large egg masses, often up to 10 cm above water on emergent vegetation.

Cipangopaludina and *Pila* are Asian genera, the latter distinguished from *Pomacea*, which is essentially Neotropical, by having a calcified rather than horny operculum. All have been deliberately introduced to Hawaii for one or both of two reasons: 1) for harvesting, or even culture, for food, and 2) as domestic aquarium snails. They are recorded from the islands of Oahu, Kauai, Maui and Hawaii. While some see their culture in positive terms as a source of revenue, others complain that taro crops are being damaged by increasing populations of the snails. The snail farmers insist that their snails cannot escape and pose no problem.

Thus far, little concern has been expressed over other more fundamental ecological problems these snails might cause, such as destruction of native freshwater habitat, competition with native freshwater snails, disease transmission, etc.

MYSTERY FLUKE IN *MELANOIDES TUBERCULATA* (GASTROPODA: THIARIDAE) IN THE SAN ANTONIO ZOO, SAN ANTONIO, TEXAS

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The introduced thiarids, *Thiara granifera* and *Melanoides tuberculata,* are now both involved in trematode cycles in North America. *Philophthalmus gralli*, an Oriental eye fluke, was first reported in *T. granifera* in San Antonio, Texas in 1969 and in New Braunfels, Texas in 1975. In October, 1990, rediae and cercariae of a monostome fluke were discovered in *M. tuberculata* in the San Antonio Zoo. North American keys to trematodes place the cercariae in one of three families: Notocotylidae, Nudacotylidae, or Pronocephalidae; however, the mystery cercariae disagree with these family descriptions by having stylets (teeth) in the acetabulum, by not showing prominent adhesive glands, and by not forming metacercariae. These differences suggest that the fluke was introduced from another geographical area. To date, we are unable to find the host with the adult fluke. At some sites in the zoo, rates of infection are as high as 80% of the snails with populations of 300-400 snails/m^2. Additionally, *M. tuberculata* is here reported as an intermediate host for *P. gralli* in the zoo.

LOOKING UP THE WRONG END: ANATOMICAL CHARACTERS OF FRESHWATER BIVALVES (MOLLUSCA: UNIONACEA)

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Early work on the recognition of higher taxa within unionaceans was done by Lea, Rafinesque, Say, Conrad, Agassiz, and von Ihering. Simpson continued this endeavor using the marsupial structure of demibranchs as a basis of classification. Ortmann finally developed a classification of Unionacea using a suite of anatomical characters. Several unsatisfactory classifications have been proposed based on a single character or limited suite of characters. Davis and Fuller tested Ortmann's classification with biochemical techniques and concluded that it was basically sound. A constant criticism is the apparent lack of usable anatomical characters for analysis of the relationships among taxa. The rectal area of bivalves has been overlooked by most authors describing bivalve anatomy. At least 12 new anatomical characters are identified from this area. Rectal characters are analyzed and the resulting tree is compared with the tree developed from the Davis and Fuller data. The two data sets are combined and that tree is presented. Although these preliminary analyses use only a portion of the diversity of North American unionids, this new data set adds a new dimension to the development of a phylogeny for North American Unionacea.

MOLLUSCA-ANNELIDA-ARTHROPODA: A PHYLOGENETIC ANALYSIS OF SPIRALIANS FROM MORPHOLOGICAL AND 18S rRNA SEQUENCE DATA

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Shared segmentation of annelid and arthropod body plans has led to the conventional hypothetical grouping "Articulata." Conflicting embryological and larval characters support an alternative annelid-mollusk grouping. The first published cladogram of metazoans accompanied by an explicit matrix of morphological characters (Meglitsch & Schram, 1990: *Invertebrate Zoology*, 3rd ed.) depicts support for the "Articulata" hypothesis. Reanalysis of this matrix, however, fails to repeat this result. Instead, 1422 trees of one fewer step were found, whose strict consensus lacked resolution for spiralian taxa. Our independent study of a larger matrix for 17 phyla of morphological data combined with, or analyzed separately from, available 18S ribosomal RNA sequence data also fails to support "Articulata." Rather, weak evidence supporting a "Eutrochozoa" clade, excluding arthropods, is presented.

THE APLACOPHORA AS PROGENETIC ACULIFERA

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Progenesis is proposed as the evolutionary process by which the Aplacophora acquired a highly derived worm shape while retaining an apparently primitive internal organization. Evidence for progenesis is (1) developmental ease of acquiring a worm shape through elongation of an embryo; (2) similarity in internal organization between less and more elongate species; (3) lack of internal specializations in contrast to the vermiform chiton *Cryptoplax;* (4) small size of most Aplacophora, important in the deep sea, and probably early maturation; and (5) presence of character states which are less developed than those of homologous characters in other mollusks.

An archimollusk is proposed with the plesiomorphies of metamerism and a dorsal cuticle stiffened by $CaCO_3$ but without organized external shell or spicules. The Conchifera (shelled mollusks including Monoplacophora) took separate evolutionary pathways to externalize $CaCO_3$ as shown by the ontogeny of shell in the Conchifera and spicules and shell plates in the Aculifera. Both groups were derived independently from nonaculiferan ancestors. The spicules of Aplacophora and Polyplacophora are therefore considered to be a synapomorphy and the shell plates of Polyplacophora an autapomorphy. The resulting cladogram allows Monoplacophora to evolve at the same time or earlier than the Aculifera, which retained some metamerism in the chitons but lost it in aplacophorans through progenesis.

PHYLOGENETIC SYSTEMATICS OF THE RECENT SUBFAMILIES OF VOLUTIDAE (GASTROPODA: PROSOBRANCHIA)

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Character states for 27 characters of shell morphology, ultrastructure, anatomy and reproductive biology are described and tabulated for 22 genera representing all ten subfamilies of Volutidae that have Recent representatives. Characters are polarized on the basis of outgroup comparison, and a phylogenetic hypothesis of the relationships of these taxa proposed. Data from these analyses are used to reassess the higher taxa in the family, and to shed light on their relative age and biogeography.

PHYLOGENETIC RELATIONSHIPS IN THE SUBFAMILY ODONTOCYMBIOLINAE (GASTROPODA: VOLUTIDAE): PRELIMINARY RESULTS

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Phylogenetic relationships are poorly known within the Volutidae, in spite of the relatively small number of species in the family. Phylogenetic analysis based on anatomical radular and shell characters provides a hypothesis about the relationships at the generic level in the volutid subfamily Odontocymbiolinae. Outgroups considered are the genera *Alcithoe* and *Nanomelon,* subfamily Zidoninae. Accessory salivary glands loosely wound around the primary salivary glands represent a synapomorphy for Odontocymbiolinae + Zidoninae. The two subfamilies apparently constitute a monophyletic group within the Volutidae. The four odontocymbioline genera differ from the outgroup by the presence of a tubular extension in the anterior part of the stomach, closed sperm duct and prostate, and rachidian tooth with cusps well separated from the basal plate. Further transformation of these characters define the hierarchy within the subfamily, beginning with the more primitive genus: *Miomelon, Tractolira, Odontocymbiola* and *Minicymbiola.* Characters traditionally used in volutid systematics such as shell sculpture and the shape of basal lobes are homoplasies in the Odontocymbiolinae. The generic status of *Minicymbiola* is doubtful: no autapomorphies distinguish this "genus" from *Odontocymbiola.*

PRELIMINARY IDEAS TOWARD A REVISION OF THE OVULIDAE (GASTROPODA: CYPRAEACEA)

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About 400 specific and 65 generic names have been given to living ovulids. Taxonomy of the Ovulidae is in disarray as almost all taxa have been named on the basis of shells alone. Cate, the last worker to monograph the group, recognized about 240 species. Comparative studies of large suites of specimens show many Indo-Pacific species to have much broader geographic ranges than previously thought; there is little endemism. Size, shape and color of ovulids are often affected by their hosts. Many species are highly variable and have been named several times as a result. I currently recognize about 160 species in the family. Generic level revision of ovulids must be based on anatomical and biochemical studies. The anatomy of only a few species has been reported. Published photographs of live animals and radulae are useless unless the corresponding shells are illustrated, or deposited in a museum; almost half of the identifications of ovulids in the literature are incorrect. Of the 65 available generic names, 16 are invalid by synonymy of the type species with that of another genus. Another dozen might be synonymized on the basis of current knowledge of the animals.

THE UTILIZATION OF GROWTH TRENDS IN SHELL DEVELOPMENT TO STUDY STROMBID PHYLOGENY AND SYSTEMATICS

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Using computer simulations, Harasewych and others have shown that the helically coiled growth plan of gastropod shells can be approximated by a series of points each describing a logarithmic spiral in a plane perpendicular to the coiling axis while undergoing exponential translation in a direction parallel to that coiling axis; the many variations in shell shape being a function of (a) the generating curve defined by the points at any moment in time, (b) the rate of spiral expansion, and (c) the rate of exponential translation. While members of the Strombidae family exhibit these general gastropod growth features, it has been observed that, among all recent and fossil taxa studied to data, there exist predictable ontogenetic changes in both the rate of spiral expansion and the rate of exponential translation. In addition, these taxa produce axial and spiral sculptural features that also exhibit predictable ontogenetic changes. These ontogenetic "signals" are being studied to determine their usefulness in separating strombid taxa and delineating evolutionary lineages.

The paper will focus on the techniques used to identify and express these ontogenetic signals, the potential uses of the information obtained, and the difficulties and limitations associated with the technique.

PATTERNS AND PROBLEMS IN THE CLASSIFICATION AND PHYLOGENY OF THE NATICIDAE (GASTROPODA)

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The Naticidae are well known as predatory marine prosobranchs with a cosmopolitan distribution in infaunal habitats. Their Recent diversity (over 200 species in 35 genera) is matched by the extensive fossil record (about 30 extinct genera). The problems of the origin and relationships of this family are considered; the status of the Triassic 'naticids' remains elusive.

The patterns of species diversity and generic macroevolution from the Jurassic to the Recent are discussed, along with the broader limitations of such analyses. Previous generic classifications of this family are compared with an ongoing reanalysis of the available data. Future approaches and prospects in the study of naticid phylogeny are outlined .

ANATOMY AND PRELIMINARY GENERIC REVIEW OF THE *BITTIUM* GROUP

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The anatomy of seven members of the *Bittium* group is described, clarifying the status of the genus-level taxa comprising it. *Bittium reticulatum*, the type species of *Bittium* Gray is described in depth, thereby establishing a criterion for other component taxa. The type species of *Stylidium* Dall and representatives of *Bittiolum* Cossmann, *Cacozeliana* Strand and *Bitinella* Dall are examined and compared with *Bittium*, s.s. Results reveal five different anatomical groups indicating that the *Bittium*-group should be divided into five genus-level taxa under subfamily Bittiinae Cossmann. Synonymies of the higher taxa and representative species examined are presented.

POTENTIAL PYRAMIDELLID PARADIGMS

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The morphologies of 8 pyramidellid species, representing 6 genera from the western Atlantic and Indo-Pacific are described and compared. Cladistic analysis for 18

characters indicates that the 8 species can be separated into four distinct clades. Softpart morphology, particularly copulatory organs and trophic apparatus, are useful in determining propinquity. While, the traditional usage of shell characters to define pyramidellid taxa can result (and not surprisingly) in the assignment of species to the wrong assemblages, conchological differences (at least for 2 Indo-Pacific species) are the sole way to distinguish between them.

PROSOBRANCH FUNCTIONAL MORPHOLOGY: WHAT'S AFOOT IN A SEA OF SLIME?

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A review of over 1000 papers from the recent and not-so-recent literature on the functional morphology of prosobranch gastropods reveals that there are specific gaps in our understanding of certain structures, and especially of their function. The habitual use of vertebrate terminology to describe guts and gonads to the neglect of function has resulted in cartilages that aren't and glands that absorb. The shift from light to electron microscopy reveals fascinating details of cellular and subcellular organization, but too often with complete disregard for the organ or organism. Fortunately, exceptions exist that serve as models for the future of functional morphology. Three priorities arise from this study: (1) that function be considered as an integral part of the structure being described; (2) that levels of organization be viewed as parts of a continuum rather than as isolated entities; and (3) that a structure and its function be placed in the context of the whole organism upon which natural selection is acting. (Funded in part by NIH-MBRS RR08102, NSF-RIMI RII-8903827, and UPR-FIPI.)

RADULAR VARIABILITY IN THE HERBIVOROUS MESOGASTROPOD *LACUNA:* INTRA- AND INTERSPECIFIC PATTERNS

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Variability in the shapes of radular teeth is uncommon within species of herbivorous gastropods. However, such variability has been reported for several species in the genus *Lacuna,* all of whom live on and consume marine macrophytes. The degree of tooth shape variability reported is as extreme as that seen among species in other groups and probably influences the functional ability of these radulae to rasp different algal food items. This reported variability could be the result of sibling species, hybridization among closely related species, ontogenetic changes in radular morphology within species, genetic polymorphisms within species, or phenotypic plasticity within individuals. Protein electrophoresis and morphological analyses (of shell and radular characteristics) are being used to test among these alternatives for a variety of North American and European species of *Lacuna.* Initial results indicate that for some species this variability is not due to hybridization or an ontogenetic change in morphology and can be phenotypically plastic within individuals.

A COMPARISON OF OPISTHOBRANCH, PROSOBRANCH, AND CRUSTACEAN FEEDING ON GREEN ALGAE

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The feeding of small marine herbivores was examined for two Oregon rocky shore habitats. In the low intertidal zone, the sacoglossan opisthobranch *Placida dendritica* numerically dominated the fauna on the green alga *Codium setchellii* during spring and summer; the prosobranch snail *Lacuna* sp. dominated in fall and winter. *Placida* consumed the alga more rapidly than did co-occurring *Lacuna*, amphipods, and isopods. Slug herbivory may restrict *Codium* from certain shores.

In high intertidal, saline pools, the large sacoglossan *Aplysiopsis smithi* was frequent, though not abundant in summer. Slug feeding (per individual and unit biomass) produced significantly more tissue loss to the green algae *Cladophora columbiana* and *Chaetomorpha linum* than did feeding by the prosobranch snail *Littorina* sp., amphipods, or isopods. *Aplysiopsis* reduced *Chaetomorpha* abundance, thus altering algal community structure in saline pools. Hence, opisthobranch feeding may not only exceed that of coexisting prosobranchs and crustaceans but also affect the abundance of green algal hosts.

RADULAR STRUCTURE OF *SMARAGDIA* (GASTROPODA: NERITIDAE): A CYTOPLASM-FEEDING SEAGRASS ASSOCIATE

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Smaragdia bryanae grazes specifically on the leaf cell tissue of *Halophila hawaiiana*, the only seagrass found in the Hawaiian Islands. The sharp-cusped shape and size of the outer lateral tooth of the radula is close to the size of individual leaf cells, and matches the holes cut in the leaf epidermis during grazing. The snails are thought to feed on cytoplasm as the cells are pierced, can opener fashion, by the outer lateral cusps. No observable feces were produced during grazing on seagrass for extended periods in the laboratory, consistent with a cytoplasm-feeding mode, where most of the material taken in is digestible.

The similar radulae of the other species of *Smaragdia*, all associated with seagrasses, suggests that they feed on their hosts in the same manner. This unusual feeding mode is unique within the Neritidae, all microfloral grazers, and explains the divergent radular structure of this genus. The basic plan of the radula seems neritid, but all of the teeth have significant shape differences from other nerites. However, characters of the central outer lateral and marginal teeth are shared with members of the terrestrial Neritacean family Helicinidae. The possibility of a terrestrial history is also suggested by the close and widespread association with seagrasses (descendants of land plants), extending back at least to the Miocene, where fossil *Smaragdia* are consistently found with fossil seagrasses or their associates.

COMPARATIVE FEEDING BIOLOGY OF *ACTEOCINA CANALICULATA* (SAY, 1826) AND *HAMINOEA SOLITARIA* (SAY, 1822) (OPISTHOBRANCHIA: CEPHALASPIDEA)

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The feeding biology of two southern New England cephalaspid species, *Acteocina canaliculata* (Say, 1826) and *Haminoea solitaria* (Say, 1822) was examined. *Acteocina canaliculata* fed on bivalves, including *Gemma gemma* (Totten, 1834), and three suborders of foraminiferans: Textulariina, Miliolina, and Rotaliina. The proportion of miliolin forams in the diet of *Acteocina* decreased while bivalves increased with increasing size of *Acteocina*. In addition no bivalves were found in the guts of snails < 5.0 mm in shell length, probably reflecting an inability of small snails to ingest large prey. The snails appeared to locate prey with the aid of Hancock's organ and sensory patches situated along the anterior edge of the cephalic shield and foot. Individual prey were grasped with the radula and pulled whole into the buccal cavity. Sediment appeared to be passively removed by the jaws.

Haminoea solitaria ingested sediment containing diatoms, unidentified algae, and detritus. Snails appeared to feed indiscriminately on food items in proportion to their relative abundance in the environment. Hancock's organ and sensory patches did not aid in the selection of specific food particles, but may be involved in locating areas where diatoms and algae are abundant.

STALKS, SLOPES, AND TRAILS: THE EFFECT OF CONFLICTING DIRECTIONAL CUES ON THE ORIENTATION OF THE MARSH PERIWINKLE *LITTORINA IRRORATA*

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The marsh periwinkle *Littorina irrorata* has been shown to utilize a variety of orientation cues, including beach slope, grass stalks, and conspecific mucous trails, to maintain its position in the intertidal zone. Although *L. irrorata*'s response to visual stimuli has been well documented, the interactions and relationships that exist between these redundant orientation cues is poorly understood. In this study, I compared the responses of groups of snails to individual cues (conspecific trails, visual stimuli, and a 5° slope) as well as pairs of cues presented simultaneously but in conflict with one another. Snails oriented significantly to all three stimuli but snails crawling in response to conspecific mucous trails had the shortest trail lengths and the least circuitous paths. Snails presented with a choice between a mucous trail and a slope preferred the trail. Orientation became bimodal and equal numbers of snails responded to the trail and artificial stalk when the two cues were offered simultaneously. Moreover, snails appeared to weigh conflicting directional information provided by both the slope and artificial stalk equally, resulting in a mean vector angle located between the two stimuli.

AGGRESSIVE AND REPRODUCTIVE BEHAVIOR OF CAPTIVE *OCTOPUS BURRYI* (MOLLUSCA: CEPHALOPODA)

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A number of immature *Octopus burryi* Voss, 1950, were captured in Narragansett Bay, Rhode Island, from August through November, 1990. Apparently these individuals were transported north of Cape Hatteras as planktonic paralarvae which settled out locally and assumed the benthic adult life style. A pair was captured by the author and maintained in the laboratory for nearly 3 months. Although the male outweighed the female by 50% initially (33g vs. 19g wet wt.), the female rapidly assumed and retained dominance thenceforth. After some 60 days the female outweighed the male by 50% . Copulation was first observed for this species, beginning about 3 weeks prior to the onset of spawning. Total egg biomass (71 g) was some 41% of the female's maximum pre-spawning biomass. The eggs proved fertile, but no hatchlings survived more than a week. Photographic documentation of a variety of *O. burryi* behavior and color patterns will be presented and compared with those of related species.

OCCURRENCE OF THE NORTH PACIFIC GIANT SQUID IN PUGET SOUND, WASHINGTON

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The North Pacific giant squid, *Moroteuthis robusta* (Verrill, 1876), is commonly caught by trawlers over its range in the North Pacific from 100-600 m deep. It is considered a rarity to find it in Puget Sound, which has sills and reduced salinity, and as such is reported as an oddity to the press or institutions such as the Seattle Aquarium. Reports of the animal collected over the years indicate it is a more frequent visitor than previously thought. Little is known of their habits, migrations, or food, although one animal donated to the Aquarium from the Gulf of Alaska was caught with Atka mackerel, a pelagic greenling, which is a probable food source. It has been speculated that they follow salmon migrations into Puget Sound.

AQUARIUM HUSBANDRY OF THE SEPIOLID SQUID *ROSSIA PACIFICA* (BERRY, 1911)

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The stubby squid, *Rossia pacifica*, has been on public display at the Seattle Aquarium almost continually for eight years. A brief description of the animal is given along with its life history, field aspects, and previous cultivation efforts. The history of its aquarium maintenance is detailed with aspects of its public display, collecting techniques, commonalities of collection sites, and feeding regimens.

STUDIES ON THE SHALLOW WATER POLYPLACOPHORA OF NUEVA ESPARTA, VENEZUELA

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Collections of Polyplacophora from Isla de Margarita and shallow water dredging near Isla Coche, Nueva Esparta, Venezuela, have greatly increased the number of chiton species recorded from this area. We now report 17 species including: significant range extensions of *Callistochiton portobelensis* Ferreira, 1976, previously known only from the Caribbean coast of Panama, and *Ischnochiton papillosus* (C. B. Adams, 1845), reported previously only from the Greater Antilles; two undescribed species of *Lepidochitona*; and an undescribed species of *Acanthochitona*. The presence of *Acanthochitona rhodea* (Pilsbry, 1893) and *A. pygmaea* (Pilsbry, 1893) in Venezuelan waters is confirmed. *Chaetopleura apiculata* (Say, 1834) known from the eastern coast of the United States, commonly occurs in the shallow waters of Isla de Margarita.

COMPARATIVE ANATOMY OF *MYCETOPODA* AND *ANODONTITES* (MYCETOPODIDAE) FROM CENTRAL AMERICA WITH *MUTELA* (MUTELIDAE) FROM EAST AFRICA

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Scanning and transmission electron microscopy and histology were employed to investigate the external and internal anatomy of the ctenidia, the external structure of the oral and aboral surfaces of the labial palps and the ciliation of the incurrent and excurrent siphons of *Mycetopoda siliquosa* (Spix, 1827), *Anodontites nicaraguae* (Philippi, 1848), and *A. montezuma* (Lea, 1841) of the Central American Mycetopodidae and *Mutela nilotica* (Cailliaud, 1823) of the East African Mutelidae. The unique circulatory system of the mycetopodid ctenidia and ctenidial ciliation are described in detail. The bizarre theca containing the developing frontal cilia of the ctenidia of *Mutela nilotica* are described from early development to maturation. The surfaces of the labial palps, as well as the ciliation of the incurrent and excurrent siphons, are compared. These results confirm the higher level classification erected by Parodiz and Bonetto in their landmark contribution of 1963.

PATTERN FORMATION IN CYPRAEID GASTROPODS: SUPPORT FOR DIFFUSION-REACTION MODELS

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The determinate growth mode and adult pigmentation patterns exhibited within the cypraeid group provide a system for testing hypotheses concerning pattern formation during shell secretion in mollusks. Color patterns developed on the prograding margin during juvenile shell growth can be modeled by both a diffusion-reaction and a neural sensory hypothesis. However, infrequent aberrations seen in adult color patterns favor the diffusion-reaction model to the exclusion of any pre-sensory aspect during shell biomineralization. Because adult pattern formation occurs relatively instantaneously during shell formation, disruptions in this system allow a test for the realignment of mantle secreting cells. Non-alignment seen in specimens with disrupted adult patterns indicates that the tasting of the previous material does not occur. Both *Cypraea cribraria* and *C. arabica* display a direct one-to-one correspondence between mantle papillae and underlying color markings. A heterogeneous condition within the hemolymph may be established by the irregularity of the outer epithelial papillary surface that creates a condition for non-random pigment expression. Diffusion-reaction models require such heterogeneous conditions along initiating surfaces. Thus, a two-dimensional diffusion-reaction model is adequate to explain the adult markings in cypraeids. This model establishes a heterogeneous condition distal to the surface of secretion within the hemolymph derived from the irregular papillary surface. Simultaneously, a field of activation is generated that reads these incongruities and deposits pigments accordingly. Historically, when compared to other related groups (Ovulidae and Velutinacea), the cypraeids have developed these color patterns recently as a result of both gaining papillae and depositing a final adult shell layer. This study emphasizes the importance and benefit of seeking explanations for aberrations in order to better understand more general processes.

THE INTERTIDAL: PHYSICAL AND BIOLOGICAL INFLUENCES ON SPECIES COMPOSITION, ABUNDANCE AND RECRUITMENT PATTERNS IN THE NORTHEAST PACIFIC OCEAN

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The intertidal environment is unique in that it is exposed to both meteorological and oceanographic climate events, with typically wide temperature and salinity fluctuations over relatively short time durations. Intertidal species high in the subtidal have to primarily cope with terrestrial competitors or predators while those low in the subtidal have to primarily cope with marine examples. This interaction of the physical and biological environment has tended to result in marine species which either move in and out of this zone with the tides or if sedentary, have a hard, impermeable exoskeleton or show burying behavior to allow them to avoid both predation and adverse physical conditions. Nevertheless, a pronounced zonation of species occurs and because of the relatively short geographic distances involved, this marine environment is likely to be the first obviously impacted by any pronounced pattern of climatic change. Physical and biological events and their probable consequences on the distribution and recruitment of commercial species inhabiting the intertidal are discussed, with consideration of the magnitude of change and data time series required to produce statistically significant effects.

SAN NICOLAS ISLAND MACROINVERTEBRATES: PAST AND PRESENT

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Although various studies have focused on intertidal marine life of San Nicolas Island, no comprehensive collection of modern macroinvertebrates has been conducted on this island. I compared modern and Pleistocene Age (120,000 years B.P.) macroinvertebrates of San Nicolas Island, the outermost of the eight Channel Islands located off the coast of southern California. From 24 August 1990 to 28 February 1991, I conducted a comprehensive sampling of beach casts on specific beaches and in tide pools. Modern molluscan, cirriped, and echinoderm species were collected and identified. In total, 146 species of macroinvertebrates were sampled. I identified 90 gastropods, 2 chitons, 45 bivalves, 1 cephalopod, 4 echinoderms, and 4 cirripeds.

With a few exceptions, the modern macroinvertebrate fauna collected on San Nicolas Island resembled the native Pleistocene deposits dated by Norris and Vedder (1963).

RECONSTRUCTING THE HISTORICAL BIOGEOGRAPHY OF *FISSURELLA (FISSURELLA)* BRUGUIERE, 1789: A PHYLOGENETIC APPROACH

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Evolutionary relationships between 26 extinct and extant members of *Fissurella* (*Fissurella*) Bruguiere, 1789 are examined using parsimony methods. Based on a phylogenetic analysis of 37 anatomical, radular and conchological characters, *Fissurella* (*sensu stricto*) is a monophyletic taxon consisting of Clade A and Grade B. The most derived members of *Fissurella* (*s.s.*) belong to Clade A. These taxa extend from the Pliocene of Chile and South Africa to the Recent of Peru, Chile and Argentina. Members of Grade B, containing the most primitive representatives of *Fissurella* (*s.s.*), are known from the Pliocene of Venezuela, Chile and South Africa. Because relationships between these primitive taxa are unresolved, a temperate or tropical origin for *Fissurella* (*s.s.*) is equivocal; however, paleontological evidence indicates that derived members of this clade arose before the closure of the Panamic Portal (3.1 Ma) and dispersed into the northeastern Pacific during the Pliocene or Pleistocene. Extant *Fissurella* (*s.s.*) species exhibit an antitropical distribution (McLean, 1984:18; Lindberg, in press). Combined phylogenetic and paleontological evidence demonstrates that this geographic pattern has resulted from dispersal and vicariant processes.

ASPECTS OF THE LIFE HISTORY OF A MINUTE, OVOVIVIPAROUS BIVALVE, *GONIOCUNA DALLI* (BIVALVIA: CONDYLOCARDIIDAE) FROM THE NORTHERN GULF OF MEXICO

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Goniocuna dalli (Vanatta, 1904) is a minute ovoviviparous bivalve found along the northern Gulf of Mexico between the Mississippi River and Apalachicola Bay, Florida. Very little is known of the ecology, physiology, or morphology of this clam. To study several aspects of the life-history of *G. dalli*, collections were made on West Ship Island, Mississippi between August 1990 and April 1991. Length, sex, and reproductive data were recorded. Clam length rarely exceeds 2.5 mm and young are released at a length of approximately 0.3 mm. A greater fraction (>60%) of large (>1.5 mm) clams were found to be brooding females . The overall population's male/female ratio was very low (1:4); however this ratio increased (1:2) in smaller size classes. Brood size increased considerably with female sizes above 2.0 mm. The average brood size was 10 in clams less than 2.0 mm, and in larger clams the average brood size was 25. Two developmental stages were recognized within the broods: unshelled and shelled. Data from August 1990 suggests that the brood stage is not dependent on parental size and that broods are sequential, both stages can be found in a single female.

PALEOCLIMATIC IMPLICATIONS OF LATEST EOCENE AND EARLY OLIGOCENE LAND SNAILS (PULMONATA: STYLOMMATOPHORA) FROM EASTERN WYOMING

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The White River Formation near Douglas, Wyoming, contains 13 genera (13 spp.) of land snails. All are referable to modern families and most to modern genera. The formation was deposited continuously across the Eocene-Oligocene boundary, and includes the upper Eocene Chadron and lower Oligocene Brule members.

A major change in land snail faunas occurs at the Chadron Brule contact. Chadron land snail faunas are characterized by taxa now living in the Central Mexican Plateau and the southern-most Rocky Mountains (*Ashmunella, Holospira,* and a new genus closely related to *Humboldtiana*). Brule land snail faunas include genera now living in southern California and northern Baja California (*Xerarionta, Micarionta)* and taxa now living in the southern Rocky Mountains (*Ischnopupoides Gastrocopta, Radiocentrum).* Large-shelled *Xerarionta* are abundant in the lower Brule, but are less abundant than the microshelled taxa *Ischnopupoides*, *Gastrocopta* and *Radiocentrum* in the middle Brule. This change reflects a decrease in available leaf litter shelter, associated with increased drying. A land snail fauna within a middle Brule paleovalley fill contains a normal Brule fauna with the addition of *Polygyrella*, *Mesomphix*, and *Mesodon*(?). These snails indicate a local increase of moisture and leaf litter habitats. The distribution of modern analog taxa provides estimates of climatic parameters such as mean annual temperature and precipitation.

BIOGEOGRAPHY AND SYSTEMATICS OF *POLYGYRA* LAND SNAILS FROM WESTERN MEXICO AND SOUTHERN U.S.A.

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While working on descriptions of new species of land snails from Mexico, we noted that the systematics of *Polygyra*, having over 70 species, needs to be revised. Shell and genital characters in a cladistic analysis produced a phylogenetic hypothesis differing from traditional classifications in several important details. The undescribed Mexican *Polygyra* are members of a western Mexico group of species. Biogeographical analysis supports the idea that western Mexican *Polygyra* are derived from *Polygyra* in southern U.S.A. Future phylogenetic analyses of this group will incorporate molecular data being gathered by other malacologists .

LEAF-LITTER MALACOFAUNA OF A TROPICAL RAIN FOREST: PRELIMINARY RESULTS

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Land snails are known to be part of the leaf litter fauna, and decomposers. It is necessary to know the mollusk fauna inhabiting the leaf litter and humus, to understand the feeding relations of that fauna. The objectives of this project are: 1) characterize the malacological fauna present in leaf litter of the tropical rain forest, and 2) to study the feeding habits of some of the species found there (fecal analysis; tests are in progress).

Monthly samples are being used to determine if there is a difference between the fauna in the leaf litter of two different species of trees: *Ficus yoponensis* Desvaux (leaf litter of fast decomposition rate) and *Nectandra ambigens* (Blake) (low decomposition rate).

The following are results of one year (April 1990 to April 1991) sampling.

Preliminary results show 15 families, 20 genera, six identified species, and four species to be confirmed, comprising 40 taxa present in the leaf litter of both trees.

Most of the specimens are micromollusks, including young specimens of large snails (*Omphalina, Euglandina, Streptostyla*).

The taxa most frequent in the samples are *Helicina* sp., *Euconulus* sp., *Guppya* sp., *Hawaiia minuscula* (Binney, 1840), *Thysanophora* sp. B and *Synopeas beckianum* (Pfeiffer, 1846). Rare specimens are *Streptostyla mitraeformis* (Shuttleworth, 1852), *Omphalina* cf. *zonites* (Pfeiffer, 1845), *Lamellaxis* sp., and specimens of the family Vitrinidae.

During the twelve months of study only 27 live specimens have been found out of 1094 shells.

Four families found are basically tropical (Helicinidae, Ferrussaciidae, Subulinidae, cf. Achatinidae), as is the genus *Guppya* (Euconulidae).

Three families are American. Spiraxidae and Thysanophoridae are from North America to Central America or South America, and the Caribbean Islands. Megalostomatidae is found in East Mexico, Guatemala and the Antilles.

Two families (Vitrinidae and Punctidae) are mainly Holarctic.

The Systrophiidae is primarily South American.

The Strobilopsidae possess a disjunct distribution from the Americas and Asia. It ranges throughout North America, Central America, the Galapagos Islands, part of South America and the Antilles, and it is found on the coast of the Soviet Union, Japan, China and the Philippines.

Finally, two families are cosmopolitan (Pupillidae and Endodontidae).

So, the main faunistic components are tropical and American, with the cosmopolitan, holarctic, and the South American components occurring in smaller proportions.

EXPERIMENTAL BIVALVE TAPHONOMY: ANALYSIS OF THE EFFECTS OF CHEMICAL DISSOLUTION AND MECHANICAL ABRASION BY SIZE CLASS IN *DONAX GOULDII* DALL, 1921

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Studies of well-preserved fossil bivalve populations frequently assume a lack of significant taphonomic bias. Most taphonomic experiments have been designed to generate results in which destruction is obvious. This study compares the less obvious taphonomic effects of experimental physical abrasion and chemical dissolution on three size classes of a Holocene population of *Donax gouldii* Dall, 1921. It is designed to provide a framework for assessing more subtle forms of taphonomic alteration in fossil bivalve populations.

Shells of three size classes of live-collected animals from Newport Beach, California, were subjected to three experimental treatments: (1) abrasion in sandy water on a rocking intertidal simulation table, (2) dissolution in an acidic solution mimicking conditions that valves might experience in natural pre-burial or post-burial settings, and (3) dissolution in an acidic solution following abrasion on the rocking table. Data indicate a tendency for greater percent weight loss in the small shell size classes. Although shells remained intact through all treatments, scanning electron microscopy shows dramatic differences between the surfaces of fresh shells, abraded shells, and dissolved shells.

Although this study does not generate a full classification of dissolution and abrasion features, it does demonstrate the potential of experimental taphonomy for detailed reconstruction of postmortem history of fossil bivalve populations.

COMPARATIVE MORPHOLOGY OF THE CRANIAL CARTILAGE IN SELECTED SPECIES OF MYOPSID SQUID (CEPHALOPODA: TEUTHOIDEA)

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Cephalopod endoskeletal cartilages, despite their apparent presence across many of the extant taxa and functional convergence with the vertebrate skeleton, have largely escaped notice and description in the scientific literature. A review of what little is known of these structures indicates that they vary in form, composition, and pattern of occurrence across different taxa; however a cranium is usually present. The results of a principal component analysis of cranial morphology in selected species of myopsid squid suggest that cranial form is conservative within the suborder Myopsida, and that interspecific variation is influenced primarily by the configuration of the brain and by environmental factors; greater variation in cranial morphology and cartilage composition appears to be present at the ordinal level. Such variation is potentially valuable in the study of cephalopodan relationships and phylogeny, and should be evaluated further as a tool in revising cephalopod classification.

FRESHWATER MUSSELS AND FRESHWATER MITES: SYMBIOSIS AND SPECIATION

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The cosmopolitan water mite family Unionicolidae includes numerous species occurring as temporary or permanent symbionts of unionid mussels. Recent taxonomic revision has revealed a plethora of unionicolid species from North American unionids. *Unionicola formosa* is reported from at least 12 species of anodontine mussels. In North Carolina it occurs principally with *Anodonta cataracta* and *A. imbecilis*. Populations of this mite from these mussels cannot reliably be separated on morphological criteria. However, mites from the two mussel species, even from sympatric host populations, differ significantly with respect to several aspects of their population ecology, as well as host-influenced and host oriented behavior. In addition to these ecological and behavioral differences, an electrophoretic analysis of 19 enzyme loci from four populations of *U. formosa* from *A. imbecilis* and two from *A. cataracta* revealed significant differences in the population genetic structure of mites from these two species of mussels. Coupled with assumptions regarding this mite's reproductive biology, these data suggest that these host-specific populations may constitute sibling species. Thus, taxonomic issues regarding this symbiotic taxon may be more complicated than currently recognized.

MODE OF REPRODUCTION AND GENETIC STRUCTURE IN AQUATIC GASTROPODS

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The population genetic structure of aquatic mollusks is determined by life history factors as well as by possible differences in selection pressures in heterogeneous environments. In gastropods, one important influence on genetic differentiation is the potential for long-distance dispersal of eggs or larvae. The available data suggest that, for marine gastropods, free-spawning species with planktonic larvae (e.g., *Stramonita*, some *Littorina)* exhibit levels of genetic differentiation that are 10-100 times lower than the differentiation over comparable geographic scales for related brooding species (e.g., *Nucella*, some *Littorina*). Among freshwater gastropods, free-swimming larval stages do not occur, but there are still differences among taxa in dispersal potential. Freshwater prosobranch mollusks produce eggs that are either brooded or deposited in large capsules, which restricts dispersal compared with pulmonate mollusks, which produce smaller eggs that are capable of at least passive dispersal. Available data suggest that these differences in dispersal potential between prosobranch mollusks (e.g., *Viviparus*, *Campeloma)* and pulmonate mollusks (e.g., *Lymnaea*) are also associated with differences in amount of genetic differentiation of populations.

THE DOMINICAN REPUBLIC PROJECT: A PROGRESS REPORT

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The continuous and faunally diverse Neogene marine sequences of the Cibao Valley in the northwestern Dominican Republic allow close examination of total assemblages and their relation to paleoenvironment and time. Field work started in 1978, and the introductory publication appeared in the *Bulletins of American Paleontology* in 1986. Since then a series of nine faunal monographs, including four on mollusks, have appeared. Three additional manuscripts, one on mollusks, are being processed, and at least fifteen more are expected in the next few years. All published data and, in some cases, additional unpublished data on the lithology, stratigraphy, and fauna of the nearly one thousand collecting localities have been entered into a dBASE IV database, which may be searched on any held and/or portions or combinations thereof.

DYNAMICS OF NATICID GASTROPOD PREDATION IN A LATE PLEISTOCENE FOSSIL ASSEMBLAGE FROM THE PALOS VERDES SAND FORMATION

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Drilling predatory gastropods leave an abundant fossil record of their activities that is useful not only in investigating patterns of interaction in paleocommunities but also in formulating and testing evolutionary hypotheses about the relationship between predator and prey species. A late Pleistocene fossil assemblage from the Palos Verdes Sand Formation of Costa Mesa, Orange County, California containing large samples of naticid drilled mollusks, especially gastropods, provides an opportunity to quantify aspects of predator prey interaction. In a three pound sample of collected material, there are nine genera of gastropods and five genera of bivalves that contain specimens with naticid boreholes in their shells. Of the gastropods, the most frequently drilled genera are *Antiplanes, Nassarius* and *Olivella.* The ratio of drilled to undrilled specimens for each group is as follows: *Antiplanes* 7/5 (58.3%), *Nassarius* 146/105 (58%) and *Olivella* 53/77 (47.6%). Of the bivalves present, the most frequently drilled genera are *Corbula, Glycymeris* and *Donax.* The ratios of drilled to undrilled for these groups are *Corbula* 1/11 (8.3%), *Glycymeris* 9/232 (3.7%) and *Donax* 35/1125 (3%). Plots of measurements of shell length against drill hole diameter and shell thickness against drill hole diameter in the valves of *Donax* test the prediction of a positive correlation between prey size and predator size. Results, $R=0.4$ for length vs. drill hole diameter and $R=0.5$ for thickness vs. drill hole diameter show a definite correlation. Data on predation frequency on specimens of *Nassarius* and *Olivella* relative to shell size test the prediction that predation is selective. Results for *Olivella* show that predation follows the size distribution of the population indicating that there is no preferential selection by naticids for large sized prey items. In contrast for *Nassarius.* Results show a significant increase in predation frequency with size suggesting that there is a size refuge for small specimens. Another three pound sample of the same fossil material is now being examined to see if similar results are obtained.

THE PRELIMINARY REPORT ON THE *PHYSA* SPECIES BY USING ISOZYME TECHNIQUE (GASTROPODA: PHYSIDAE)

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In pulmonate snails, the Family Physidae is one of the four major families of the Superfamily Hygrophila. There are at least 130 names in this family from the North American Continent alone, but only a few species are defined satisfactorily. The taxonomy of the family Physidae is in chaos; there is an urgent need to revise the family Physidae and find clear-cut characters to distinguish species. The objective of this study was to find the feasibility of using isozyme markers to identify species of *Physa*.

Horizontal starch gel electrophoresis was employed to compare populations of *Physa* collected from Colorado and Utah. Seven enzyme systems were examined and gene products of 24 presumptive loci were resolved. The multilocus genotype data were analyzed using the Biosys-1 computer program. The results indicate that the genetic variation revealed by electrophoresis will be useful in systematic studies of *Physa* at the species level.

A PRELIMINARY ANALYSIS OF A HYBRID ZONE BETWEEN *MYTILUS TROSSULUS* AND *MYTILUS GALLOPROVINCIALIS*

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A genetic analysis of *Mytilus* populations from the coast of California was conducted using protein electrophoresis. The focus of the study was intergradation and hybridization between *Mytilus trossulus* and *M. galloprovincialis*. Mussels from several habitat types were analyzed in an effort to understand the factors that maintain this hybrid zone. Principal component analysis was used to classify individual mussels as *M. trossulus*, *M. galloprovincialis*, or hybrids. Populations north of Cape Mendocino were pure *M. trossulus*. A mosaic of hybrid populations occurred between Cape Mendocino and Point Conception, and south of Point Conception populations were pure *M. galloprovincialis*. The potential factors maintaining this hybrid zone will be briefly discussed.

A NEW SPECIES OF *LOTTIA* GRAY, 1833, FROM THE NORTHEASTERN PACIFIC

Robyn A. Stuber
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An undescribed species of *Lottia* Gray, 1833, has been identified from rocky shore communities in central and northern California. This new *Lottia sp.* has previously gone unrecognized as its shell color patterns and sculpture resemble those observed in the polytypic species, *Lottia ochracea* (Dall, 1871). The lottiid radula is diagnostic at the species level and while *L. ochracea* and the new species are difficult to distinguish using conchological features, radular characters unequivocally demonstrate that *L. ochracea* and the new lottiid are distinct taxa .

There are at least two ecological forms of the new *Lottia* sp. -- a tessellate form and a solid form. These two forms may be common on smooth bare rocks in the middle to low intertidal. They also occur subtidally. There is limited evidence for epizoic and coralline forms, as well. A single specimen has been found at a depth of 15 feet on *Tegula brunnea* Philippi, 1848. In lottiids, changes in shell color pattern may indicate movement of individuals between different substrata. The fine reticulate pattern at the apices of many solid forms suggests that these individuals may be moving from coralline substrates to the smooth bare rock substratum on which they are commonly found. These four ecological forms have also been recognized in *L. ochracea* (Lindberg, 1979).

Although little is known thus far about the natural history of this new species of *Lottia*, phylogenetically, it appears to be closely related to *L. ochracea, a* taxon with which it shares many conchological and radular synapomorphies.

American Malacological Union
Western Society of Malacologists
Berkeley 1991

Minutes of
Executive Board Meeting
Western Society of Malacologists
Berkeley, California
30 June 1991

President Scott called the meeting to order at 5:01 p.m.

Present: Paul Scott, Roland Anderson, David Mulliner, Henry Chaney, Kirstie Kaiser, George Metz, Clif Coney.

Secretary's Report: The 1990 minutes were read by H. Chaney and approved as summarized.

Treasurer's Report: H. Chaney reported as follows:

As of the 1991 annual meeting, income for 1991 was $2783.00, which includes $2182.00 in dues received, and $576.00 donated to the symposium fund, for a total of $1032.00 for the symposium fund. $25.00 was earmarked for the student grant. Membership renewal rates were down, leaving $300.00 in outstanding dues, as well as 10 former members that were not expected to renew,

Net worth as of the 1991 annual meeting was $10,100.00, with $300.00 in checking, and $9,800.00 in savings. $600.00 has been spent toward the next annual meeting at Asilomar.

Student Grant: The WSM Student Grant award of $1,000.00 was given to Jay Schneider, University of Chicago. An additional $250 was awarded to Troy Gowdy Clarke, University of California, Santa Barbara. These funds were provided by the Santa Barbara Malacological Society as part of the combined student grant program.

President Scott announced that Vida Kenk will resign as Chairman, Student Grant Committee. Treasurer Chaney recommended that $50.00 be awarded for Student Best Paper in lieu of a set of WSM Annual Reports. David Mulliner moved that a one time award of $50.00 be given, which was unanimously approved.

Nominating Committee: Slate of officers for 1992 are as follows:

President	David Mulliner
First Vice President	Douglas Eernisse
Second Vice President	Kirstie Kaiser
Treasurer	Henry Chaney
Secretary	Clif Coney
Members at Large	Elsie Marshall George Metz

The above slate was unanimously approved by the board.

Annual Report: The production of the 1990 WSM Annual Report cost $3,100.00. Two hundred and fifty copies were printed with two hundred and ten copies mailed. Treasurer Chaney pointed out that the cost of the 1990 WSM Annual Report exceeded WSM dues by $900.00.

A motion to accept Hans Bertsch as Editor was made by President Scott and was unanimously approved.

1992 WSM Meeting: President-elect Mulliner announced that the 1992 meeting would be held at Asilomar, California, and that two symposia were planned: (1) Molluscan fauna of Isla del Coco, Costa Rica; (2) Opisthobranchia, organized by Gosliner and Bertsch. A further suggestion was made that a collection computerization demonstration be held at night, however this was tabled until logistics were better known. Two field trips are planned: (1) Monterey Bay Aquarium; (2) Moss Landing Marine Laboratory.

Symposia Fund: The 1991 Bivalve Symposium and workshop was underwritten by a symposia fund of $5,000. As of the general meeting, $4098.00 has been expended in support of twelve participants with amounts ranging from $148.00 to $500.00.

New Business: Gene Coan read a resolution recognizing the importance of the Latin American Malacological Congress, which was unanimously approved. Spanish translation of this resolution was provided by Edna Naranjo-Garcia.

There being no further business, the meeting was adjourned at 6:30 p.m. by President Scott.

Respectfully submitted by Clifton Coney, Secretary.

Minutes of
Annual Business Meeting
Western Society of Malacologists
University of California
Berkeley, California
4 July 1991

President Scott called the meeting to order at 5:10 p.m.

Secretary's Report: In the absence of Secretary Clif Coney during the 1990 meeting, the 1990 minutes were read by 1990 acting secretary Kirstie Kaiser.

Treasurer's Report: Treasurer Henry Chaney reported as follows:

As of the 1991 annual meeting, income for 1991 was $2,783, which includes $2,182 in dues received, and $576 donated to the symposium fund. The 1991 WSM Auction and reprint sales brought in a total of $2,750 with $151.00 resulting from reprint sales.

Student Best Paper: President Scott announced that the winner of Student Best Paper competition would receive membership in the WSM, back issues of the WSM Annual Report, and a cash award of $50. Committee member Silvard P. Kool reported that Ellinor A. Michel, University of Arizona, Tucson, won best student paper for her paper entitled "Electrophoretic and anatomical differences in *Lavigeria*: Divergence in an African rift lake endemic gastropod." Other members of the committee included Edna Naranjo-Garcia and Clif Coney.

Student Grant: President Scott reported that there were 26 applicants from four countries; and the joint WSM/SBMNH student grant award would be split between two winners: Jay Schneider, University of Chicago received $1000 and Troy Gowdy Clarke, University of California, Santa Barbara received $250.00. These awards were unanimously approved by the membership.

Roland Anderson announced the 1992 slate of officers as follows:

President	David Mulliner
First Vice President	Douglas Eernisse
Second Vice President	Kirstie Kaiser
Treasurer	Henry Chaney
Secretary	Clif Coney
Members at Large	Elsie Marshall George Metz

The 1992 slate of officers was unanimously approved by the membership.

Annual Report: Editor Hans Bertsch reported that publishing costs for the production will be reduced in the future by utilizing in-house desktop publishing.

1992 WSM Meeting: President Elect David Mulliner announced that the 1992 meeting would be held at Asilomar, California, and that two symposia were planned: (1) Molluscan fauna of Isla del Coco, Costa Rica; (2) Opisthobranchia, organized by Gosliner and Bertsch. A further suggestion was made that a collection computerization demonstration be held at night, however this was tabled until logistics could be determined as feasible. Two field trips are planned: (1) Monterey Aquarium; (2) Moss Landing Marine Laboratory.

New Business: Thirty-three papers were presented in the 1991 Bivalve Symposium. A total of $4098.00, provided by the WSM, the AMU, and the California Malacozoological Society was awarded as travel stipends to twelve participants, ranging from $148.00 to $500.00 per award. President Scott proposed support for the 1992 symposiums.

President Scott requested that Edna Naranjo-Garcia read in Spanish the address to the Latin American Malacological Congress which recognized the importance of the efforts of this Congress. President Scott presented a reading of the English translation, adopted July 4, 1991, which was unanimously approved by the membership.

Editor Hans Bertsch proposed a 25 year index to the WSM Annual Report. Discussion by the membership followed with a recommendation for further investigation of this most interesting project.

President Scott passed the WSM gavel to President Elect Mulliner.

The 1992 award committee was announced by President Elect Mulliner to consist of Paul Scott, Carol Skoglund, and Judith Terry Smith.

There being no further business, the meeting was adjourned at 5:56 p.m. by President Elect Mulliner.

Respectfully submitted by Clifton Coney, Secretary.

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT

1 October 1990 - 30 September 1991

INCOME

Membership dues	$2182.00	
Student grant donations (1992)	25.00	
Symposium fund	576.00	
Publication sales and page charges	141.00	
Interest on savings accounts	578.79	
Auction and reprint sales	2729.40	
TOTAL INCOME during period		**$6232.19**

EXPENSES

Annual report	$3106.69	
Memberships and fees	42.00	
Reimbursements to officers	244.28	
1990 Student grant	1000.00	
1991 Best student paper	100.00	
1991 Symposium expenses	1370.61	
1992 Meeting advance deposit	600.00	
TOTAL EXPENSES during period		**$6413.58**
Net (Loss) for period		(181.39)
Beginning balance (1 October 1990)		10301.10
NET WORTH on 1 October 1991		**$10119.71**

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1993 Annual Meeting - First Notice

The 1993 Western Society of Malacologists Annual Meeting will be held at the La Jolla Village Inn in La Jolla, California (north of San Diego). Meeting dates will be from Sunday, 27 June to Thursday, 1 July. For further information please contact the 1993 WSM President, Douglas Eernisse, or Henry Chaney.

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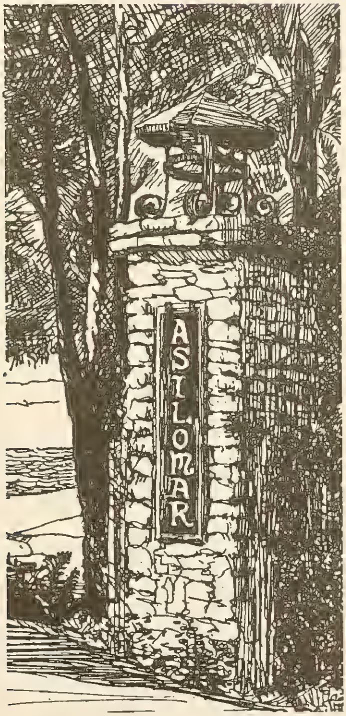

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The Western Society of Malacologists has issued two **Occasional Papers** – No. 1, "'Sea Shells of the Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; and No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan.

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INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8 1/2" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Research Associate, Department of Invertebrate Zoology, Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, California 90007 USA.

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THE ENVIRONS OF ISLA DEL COCO, COSTA RICA: PHYSICAL ASPECTS

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Cocos Island is located in the central Eastern Pacific approximately 5° north of the equator and sits 490 km off Cabo Blanco, Costa Rica, its nearest point on the continent. The closest islands, Isla Malpelo (Colombia) and the Galapágos group (Ecuador), are over 600 km away. The shape of Cocos Island is ovoid, measuring 7.6 km in length, 4.4 km in width and 23.3 km in circumference. Surface area is approximately 24 square kilometers.

Cocos Island is believed to be the product of local volcanism that occurred during the Late Pliocene. It is the only outcrop protruding above sea level from the Cocos Aseismic Ridge which rides on the Cocos Plate. The highest point on the island is Cerro Iglesias with an elevation of 634 m. There are four main embayments in which there are small beaches. The rest of the shoreline consists of vertical cliffs which extend subtidally as stepwise shelves with rubble fields. The only intertidal areas are found in the bays.

The marine biota of Cocos Island is affected by a complex interplay of three oceanic circulation patterns which vary temporally. These include an eastward flowing system which carries warm tropical water slightly north of the equator, two westward flowing cooler currents which bracket the eastward current, and a minor complex which originates near the coast of Central America. The role these cur-rents have on the diversity of island marine life varies seasonally and from year to year, with the most dramatic effects being noted during El Niño events.

DIVERSITY AND DISTRIBUTION OF MOLLUSKS AT COCOS ISLAND: A ZOOGEOGRAPHIC OVERVIEW

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An overview of the malacofauna of Cocos Island is presented which contrasts its three faunal elements: the taxa found throughout the Panamic Province, those which originate in the Indo-Pacific and those species which are endemic to the Cocos-Galapágan region.

VARIOUS METHODS OF COLLECTING MOLLUSKS AROUND COCOS ISLAND

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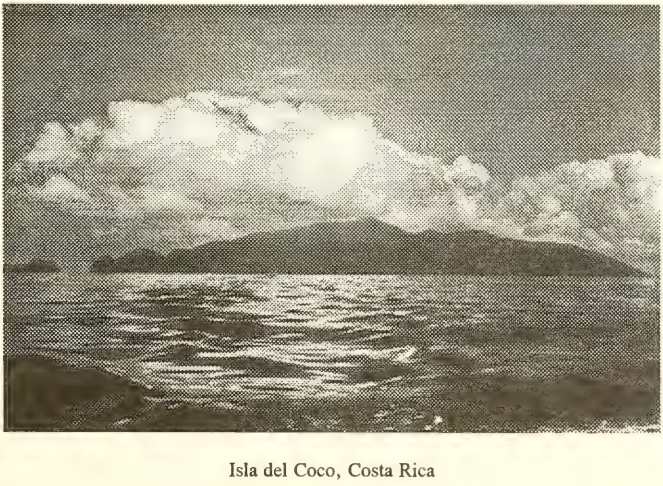
The various methods used to collect mollusks during the past nine expeditions to Cocos Island include hand collecting from the intertidal to SCUBA depths, dredging, trapping, and the deployment of benthic nets. The results of each method were illustrated by the different specimens captured. The diversity of taxa taken at SCUBA depths, down to 30 m, has been greatly increased by concentrating on micro-mollusks, through brushing the surfaces of rubble and sorting loose debris and grunge. While the use of baited traps had only limited success, the employment of a small dredge and nets extended the scope of collecting to depths of 150 m and greatly amplified the number of species now known from the Cocos region. In 1992, the use of portable global positioning systems to accurately record station data greatly aided the precision of the collecting survey.



Isla del Coco, Costa Rica

OBSERVATIONS ON CHITONS FROM COCOS ISLAND

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Chitons dredged by Dr. Donald R. Shasky from 20-120 meters depth off Cocos Island, Costa Rica (05°33'N, 87°00'W), were examined and compared to type material and previous collections from Cocos and Galápagos Islands and mainland Panamic localities. One of the three most common species was a member of *Lepidozona* that could not be confidently aligned with recognized members of this genus. The two other common species among Shasky's collections, members of *Tonicia* and *Acanthochitona*, were examined with respect to recent treatments of nominal taxa described from Cocos or Galápagos Islands. In particular, Smith and Ferreira (1977: 91) considered *Tonicia arnhemi* Dall, 1903, a subspecies of *T. forbesii* Carpenter, 1857, while Watters (1990: 247) synonymized *Acanthochitona shaskyi* Ferreira, 1987, with *A. angelica* Dall, 1919. Examination of the new material, while still hindered by limited comparative material, suggests diagnosable separation of *T. arnhemi* and *A. shaskyi* from *T. forbesii* and *A. angelica*, the latter two which have more northern type localities in Mexico. The excellent size distribution of *T. arnhemi* specimens also led to the discovery of girdle scales in juveniles. The nude adult girdle, hitherto considered diagnostic for the Toniciinae, is thus postulated as derived loss of calcareous scales based on both ontogenetic and outgroup criteria.

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Watters, G. Thomas
1990. A review of the Recent eastern Pacific Acanthochitoninae (Mollusca: Polyplacophora: Cryptoplacidae) with the description of a new genus, *Americhiton*. The Veliger 33(3): 241-271.

NEW BIVALVE MOLLUSKS FROM ISLA DEL COCO, COSTA RICA

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Two potentially new species of bivalves in the Arcidae and Pectinidae have been uncovered in samples collected at Isla del Coco by Donald Shasky, Kirstie Kaiser and Henry Chaney.

Long the bane of bivalve taxonomists, members of the Arcidae have an exceedingly variable shell morphology. Cocos specimens of *Anadara* seem most closely related to *Anadara reinharti* (Lowe, 1935), but have a very narrow, delicate hinge line and rounded antero- and postero-dorsal margins. Classic *A. reinharti* have a very thickened, robust hinge and pointed margins (see Keen, 1971; 46, fig. 88).

Isla del Coco specimens in the genus *Euvolva* (Pectinidae) are intermediate between the Panamic *E. sericeus* (Hinds, 1845) and the Californian *E. diegensis* (Dall, 1898). Ribs on the right valve of *E. sericeus* are triangular with one or two medial riblets. *Euvolva diegensis* has very broad, squared ribs with several overlying riblets, whereas Cocos material has low, rounded ribs with three to four riblets.

Further analysis of the shell morphology and anatomy will determine if the Isla del Coco specimens represent new species or just additional examples of variation in these plastic bivalves.

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OPISTHOBRANCHS OF COCOS ISLAND

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Cocos Island is an oceanic island 300 miles from the mainland of Costa Rica, with steeply sloping shorelines and very few intertidal areas. The island is swept by heavy currents. Very few opisthobranchs have been documented from the island. An El Niño year occurred during 1992. When we arrived on April 1, the water temperature was 87°F on the surface, and 85°F at 100 feet. The nudibranchs we found were very small in comparison to the same species from the Sea of Cortes. For instance, *Dendrodoris krebsii* averages 50-63 mm in the Gulf of California (Bertsch, in Kerstitch, 1989). The ones we found at Cocos Island averaged 20 mm.

Twenty-one opisthobranchs have been collected from Cocos Island.

Eight species of pelagic pteropods were collected as shells from dredging and grunge from shaking rocks into a bag. The sea butterflies are divided into two groups, the shelled and the naked. They resemble each other in the way they swim. Their parapodia are ventrally located and perform a rapid sculling motion. The shell-less Gymnosomata are collected only by near-surface or mid-water plankton trawls. The Thecosomata are also planktonic, but their shells drift to the bottom when they die. One of my favorite ways of collecting small shells is to hold a rock in a bag and shake it, dislodging the grunge material from the rock into the bag.

In the thecosome family Cavoliniidae, a number of *Cavolinia uncinata* (Rang, 1829), 4 mm long, were dredged from 100 meters depth in 1992 off Bahía Iglesia. In 1992 we also collected *Diacria quadridentata* (Blainville, 1821), 1.5 mm long, in dredge material taken from 100 meters at Bahía Iglesia. On previous trips, Donald Shasky collected *Creseis acicula* (Rang, 1828), *Creseis virgula* (Rang, 1821), and *Diacria quadridentata* from rock-shaken grunge.

In another thecosome family, Limacinidae, four species were collected during previous trips: *Limacina inflata* (Orbigny, 1836), *Limacina bulimoides* (Orbigny, 1836), *Limacina trochiformis* (Orbigny, 1836), and one unidentified species (collected by Kirstie Kaiser). All of these specimens were collected as shells from rock-shaken grunge at depths of 20-30 meters.

The other opisthobranch species are all benthic.

Reported species of Anaspidea are members of the family Aplysiidae: *Dolabella auricularia* (Lightfoot, 1786), and *Dolabrifera dolabrifera* (Rang, 1828). Both of these animals were reported from Wafer Bay in 12-14 meters depth.

Three species of Notaspidea have been collected. *Pleurobranchus areolatum* (Mörch, 1863) was taken by Donald Shasky in 1992 at Wafer Bay. *Berthellina engeli* Gardiner, 1936, was collected at Submerged Rock in 20 meters depth on a previous trip. *Tylodina fungina* Gabb, 1865, was dredged from 70 meters depth in Chatham Bay.

The two Sacoglossa species collected represent both shelled and non-shelled forms. A single *Julia thecaphora* (Carpenter, 1857) (family Juliidae) was taken by rock shaking in 20 meters depth at Manuleta. In the family Elysiidae, the only species collected was *Tridachiella diomedea* (Bergh, 1894) at Roca Sucia in 12 meters depth.

Among the dorid Nudibranchia, only five species have been collected, members of the families Chromodorididae and Dendrodorididae. In 1992, *Chromodoris baumanni* Bertsch, 1970, and two specimens of *Chromodoris* sp. were collected at Chatham Bay from 20 meters depth. The latter animal resembles *C. baumanni*, but has pattern differences (green color markings under the notum). Jim Lance states that he has found the same species from the Mexican coast of Nayarit, and Hans Bertsch has collected the species at Cabo Pulmo in the southern Gulf of California.

Dendrodoris krebsii (Mörch, 1863) was found in Chatham Bay in 1992 at 20 meters depth. We collected a red *Dendrodoris* sp. Another unnamed *Dendrodoris* was collected in Wafer Bay.

Only one aeolid nudibranch was collected in 1992. It is also unnamed, and no other aeolids have been reported from Cocos Island.

In conclusion, I believe the relative scarcity of opisthobranchs from Cocos Island in 1992 was due to the El Niño effect. More work needs to be done during normal years to establish a complete check-list of opisthobranchs from this intriguing island.

THE SUPERFAMILIES CYPRAEACEA AND LAMELLARIACEA OF ISLA DEL COCO, EASTERN PACIFIC OCEAN

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At least 13 species of cypraeaceans and three species of lamellariaceans have been documented from Isla del Coco, through literature citations and museum and private collections. Of the 13 cypraeacean species eight are true cowries of the family Cypraeidae and five are allied cowries of the family Ovulidae. All of the lamellariacean species are of the family Triviidae: two are triviids (Subfamily Triviinae); and one is an eratoid (Subfamily Eratoinae). Indo-Pacific species of Cypraeacea include at least four cypraeids and one ovulid. As yet, no Indo-Pacific lamellariacean species has been documented from Isla del Coco.

The Panamic cypraeid species *Macrocypraea cervinetta* (Kiener, 1843) and *Zonaria* (*Pseudozonaria*) *robertsi* (Hidalgo, 1906), and the ovulid species *Cypropterina* (*Jenneria*) *pustulata* (Lightfoot, 1786, *ex* Solander MS), *Phenacovolva lenoreae* Cardin and Walls, 1980, *Neosimnia aequalis* and *N. avena* (Sowerby, 1832) are here documented for the first time from Isla del Coco. The Panamic triviid *Niveria* (*Cleotrivia*) *atomaria* (Dall, 1902) and eratoid species *Hespererato oligostata* (Dall, 1902) are here documented for the first time from Isla del Coco.

The earliest documentation of the superfamily Cypraeacea from Isla del Coco was that of von Martens (1902) who cited *Cypraea* cf. *isabella* L. [= *Luria isabellamexicana* (Stearns, 1893)].

Species of Cypraeacea and Lamellariacea from Isla del Coco

The citations that follow the original author indicate the first report of that species from Isla del Coco.
* = First report from Isla del Coco
[IP] = Indo-Pacific species

Superfamily Lamellariacea
    Family Triviidae
        Subfamily Eratoinae
            **Hespererato oligostata* (Dall, 1902)
        Subfamily Triviinae
            **Niveria* (*Cleotrivia*) *atomaria* (Dall, 1902)
            Niveria (*Niveria*) *pacifica* (Sowerby, 1832); (Hertlein, 1963)
Superfamily Cypraeacea
    Family Cypraeidae
            Blasicrura alisonae (Burgess, 1983); (Ingram, 1945 [as *Cypraea rashleighana*]) [IP]

Erosaria (*Erosaria*) *albuginosa* (Gray, 1825); (Emerson and Old, 1963)
Erosaria (*Ravitrona*) *caputserpentis* (Linnaeus, 1758); (Shasky, 1985) [IP]
Luria isabellamexicana (Stearns, 1893); (von Martens, 1902 [as *Cypraea isabella*])
**Macrocypraea cervinetta* (Kiener, 1845)
Monetaria moneta (Linnaeus, 1758); (Hertlein, 1932) [IP]
Talparia talpa (Linnaeus, 1758); (Shasky, 1983) [IP]
**Zonaria* (*Pseudozonaria*) *robertsi* (Hidalgo, 1906)

Family Ovulidae
**Cypropterina* (*Jenneria*) *pustulata* (Lightfoot, 1786, *ex* Solander MS)
**Neosimnia aequalis* (Sowerby, 1832)
**Neosimnia avena* (Sowerby, 1832)
**Phenacovolva lenoreae* Cardin & Walls, 1980
Pseudocypraea adamsonii (Sowerby, 1832); (Shasky, 1989) [IP]

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REVIEW OF THE MURICIDAE AND CORALLIOPHILIDAE

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Both the muricids and coralliophilids are well represented in the Cocos Island collections. Notable examples from each family are presented with a discussion of their distribution.

INTERESTING NEOGASTROPODS FROM ISLA DEL COCO

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The prominent Cocos Island neogastropods, exclusive of the muricids, were illustrated with a particular emphasis on olives, cones and turrids. The morphological differences between island specimens and their mainland counterparts were discussed. The number of new neogastropod taxa awaiting description were reviewed, including two species of cone, a nassarid and numerous turrids.

TWO NEW LAND SNAILS FROM THAILAND

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Leaf litter samples collected in early January, 1992, by Donald R. Shasky, from Phi Phi Le and Phi Phi Don Islands, Thailand contained specimens of two new species of pulmonate gastropods. An undescribed species of *Gyliotrachela* from Phi Phi Le Island (LACM 92-2) has apertural lamellae that resemble the *G. everetti* group; however, the characteristic spiral sculpture that unites this group of species is not present in the specimens from Phi Phi Le Island. An undescribed species of *Sitalinopsis* from Phi Phi Don Island (LACM 92-3) reveals a previously unknown character, a single row of deciduous periostracal bristles that rim the carinae of each whorl. Gentle cleaning with a camel hair brush damaged all but a few of the delicate periostracal bristles, necessitating an artist's reconstruction; however, scanning electron microscopy of the few remaining bristles reveal their origin.

KARYOLOGICAL ANALYSIS OF *POMACEA FLAGELLATA* (PERRY, 1810)

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Abstract

A citogenetic analysis of the fresh water snail *Pomacea flagellata*, was made with more than 120 adults and embryonic (Figure 1) organisms. The chromosome number is 2n=26 without sex chromosomes; the chromosomic formula is 4M + 5m + 4Sm. There are 13 biarmed pairs.

The basis for comparative cytogenetic studies in the future was established and the economical importance of Pomacea was considered.

Introduction

Among the groups of aquatic organisms of economic and commercial importance, are the gastropods mollusks which have not been often studied cytogenetically (Burch, 1961).

The color, shape of the shells, morphology of the soft parts and the radula are some reference points on which the systematics are based (Inaba, 1965); the interrelationship between environmental geographic barriers, age of the organisms and other factors characterize the speciation, adaptation and selection between populations (Inaba, 1965, and Burch, 1960). More exact techniques are required to help us in the description, identification and localization of species and subspecies. Pain, 1964, says that the genus *Pomacea* is found distributed in the southeast of Mexico as far as Belize and Guatemala, represented by *P. flagellata*

The object of the present work is to establish a karyological analysis of the genus *Pomacea* from southeast Mexico.

Figure 1. Embryos of *Pomacea flagellata.*

Materials and methods

1. Collection

The organisms used in this study were collected in the "El Vapor" lagoon, Campeche, Mexico, by hand capture and using some arts of local fishing.

2. Cytogenetic techniques of Kligerman & Bloom (1977) were used, with some modifications.

At each collecting site 60 organisms were selected and washed carefully. They were injected between the shell and the gills with 0.5 ml. of KCl to 0.075 molar. After resting for two hours, the organisms were injected with an alkaloide colchicine, with a concentration of 0.02% in a proportional quantity to the weight of the organism.

The tissue was fixed with a solution of carnoy (absolute methanol--glacial acetic acid) with a proportion of 3:1, and allowed to fix for 24 hours at a temperature of 4°C (modifications made to the technique of Kligerman and Bloom (1977).

The elaborated small plates were stained with a Giemsa solution, in phosphate buffered solution, pH= 6.8.

Later the mitotic fields were analyzed and selected with a Zeiss optic microscope, counted by microphotographs, and the karyotypes were evaluated for elaborating a representative ideogram of the species.

The chromosome number in each mitotic field was counted and the chromosomes were placed in homologous pairs according to the size of the chromatids and the position of the centromer.

The karyotypes were measured using a constant magnification and the analysis was made according to the following terms:

p= short arm of the chromosome
q= long arm of the chromosome
Relative Length (R:L:) = percentage of all chromosomes
p/q + q centromeric index (C:l) = percentage of the short arm, over 1 total length of chromosome arm ratio or proportion of short arms with short or long difference.

Results

The karyological characterization of the species (Figures 2-4) showed a fundamental number of 52 with a chromosomic formula: 4M + 5m + 4 Sm (9 metacentric pairs; 4 submetacentric pairs), which 2n = 26 in the diploid phase, where it was inferred a n - 13, observed they are birramean.

The karyological characterization of the species (Table 1) was made considering the chromosome classification system proposed by Levan & Sandberg (1964).

Sex chromosomes were not identified.

The representative ideograms of the studied species are presented in this work (Figure 2).

Discussion and conclusion

Yam (1986), previously studied one species, *Pomacea patula catemacensis,* from Catemaco Lagoon, Veracruz, Mexico. It has a haploid chromosome number of 13, (2n=26). The chromosome number reported in this study in *Pomacea flagellata* from Campeche was from n=10 to 13 and 2n= 20 to 26, including possible polyploidy in these Ampullaridae.

Burch (1982) in his list of synonymous genera says that *Ampularia* Lamarck, 1799 is synonymous with *Pila* Röding, 1798 and they have been assigned to the genus *Ampularus* Montford, 1810, *Pomus* H. & A. Adams, 1856 and *Cochylium* Cuvier, 1816 as synonyms of *Pomacea* Perry, 1810.

All the organisms of *Pomacea* that I studied from the south of Mexico had 13 bivalents (n= 10 to 13 and 2n= 20 to 26) in most chromosomic fields.

Because of the lack of chromosome information in the Pomacea, little can be definitely concluded about systematics in the higher taxa. It is hoped that further studies will fill the existing gap so that we may have a clearer picture of the cytotaxonomic significance of these data.

Acknowledgments

The author wishes to express her sincere thanks to M.en C. Zoila Castillo R. for the help given in the classification of the studied species and to Andres Reda Deara for his instructive collaboration in the collection of the biological material.

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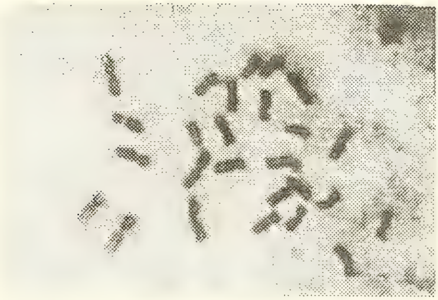

Figure 2. Birramean chromosomes (2n=26).

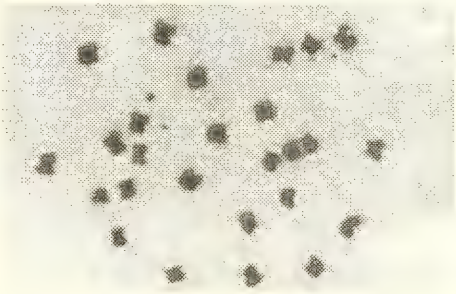

Figure 3. Chromosomes of *Pomacea flagellata.*

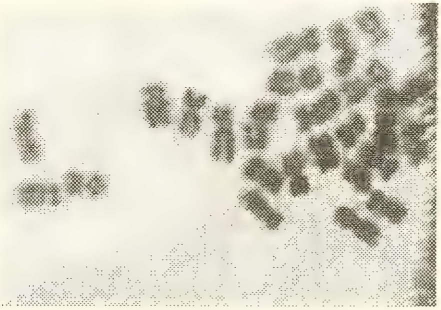

Figure 4. Chromosomes of *Pomacea flagellata.*

Table 1. Relative means for chromosome identification of *Pomacea flagellata* from "E1 Vapor" Lagoon area Campeche, Mexico. 2n= 26, n= 13.

Chromosome	Rel. length	Rel. length	R.L. p+q	R.L. p+q (1000) L.C. Hap	Centromeric index	Difference	ARM ratio	Classification
1	2.248	2.253	4.471	90.588	49.608	0.147	1.015	M
2	1.968	2.092	4.060	82.261	48.472	0.305	1.063	M
3	1.864	1.980	3.844	77.884	48.491	0.3006	1.062	M
4	1.722	1.930	3.652	73.994	47.152	0.566	1.120	M
5	1.718	2.196	3.914	79.303	43.893	1.220	1.278	m
6	1.662	2.246	3.908	79.181	42.528	1.492	1.351	m
7	1.622	2.161	3.783	76.648	42.876	1 4236	1.352	m
8	1.488	2.084	3.572	72.373	41.657	1.666	1.400	m
9	1.373	2.099	3.472	70.347	39.544	2.088	1.528	m
10	1.284	2.538	3.822	77.438	33.594	3.279	1.976	sm
11	1.303	2.391	3.694	74.845	35.273	2.942	1.834	Sm
12	1.116	2.472	3.588	72.697	31.103	3.779	2.215	Sm
13	1.484	2.091	3.575	72.434	41.510	2.902	1.409	Sm

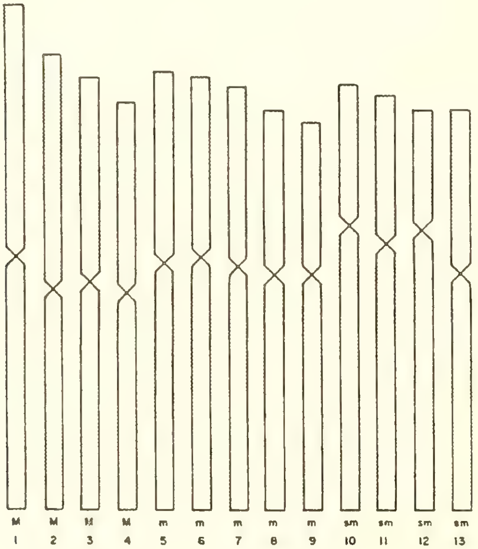

Figure 5. Representative ideogram of *Pomacea flagellata.*

LAND SNAIL LOCALITY-SPECIES LISTS

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The detailed distribution of land snails, except for the contiguous United States, Canada, and Europe, is not well documented. While preparing for a recent collecting trip to French Polynesia, the only faunal list I found was published in 1884. Consequently, the modern introductions were not included and some listed species are no longer found.

It would be very helpful if professional and non-professional collectors would make locality lists. Lists for the contiguous United States, Canada, and northwestern Europe are not needed because these regions are well documented. Tables 1 and 2 are examples of what I am proposing.

The list would only be as good as the identifications. Include the full name of the person who made the identification, and indicate whether the specimen was found dead, alive, or seen but not collected, and the date.

A combined list for a large geographic area would have less detail. If the region is small, the locations can be general (Table 3)

If the region is large, the state or province would be included. The collecting locations would be listed under the province or state (Table 4).

Table 5 is an example of the species-collector-date data. This table indicates *Elsothera ricei* Brazier, 1871 was collected by Neil E. Fahy (Collector #101) in 1991 and 1992. The other species were only collected by him in 1991.

A collectors' list would include the names and addresses for all collectors who have submitted data and their code number.

I am compiling a regional bibliography. Only distributional references are included (papers treating physiology, etc., will be omitted).

If you are interested in this listing, please send me your data. Contributors will receive a locality-species list, a species collector list, and a bibliography for their region of interest.

Land Snails Collected in Australia
January to March 1991 (#1652 to #1712)

Country	Australia														
City	Melbourne				Hobart										
Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Caryodidae															
Caryodes dufresnii (Leach, 1815)	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-
Rhytididae															
Tasmaphena ruga (Legrand, 1871)	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-
Tasmaphena sinclairi (Pfeiffer, 1845)	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
Charopidae															
Elsothera ricei Brazier, 1871	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-
Mutathena fordei (Braxier, 1871)	-	-	-	*	-	-	-	-	-	-	-	-	-	-	-
Oreomava otwayensis (Petterd, 1879)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Phillomens dandenongensis (Petterd, 1879)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Helicaroinidae															
Helicarion niger (Quoy & Gaimare, 1832)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Zonitidae															
Oxychilus dellarius (Muller, 1774)	-	+	-	-	+	+	+	-	-	-	-	-	+	+	+
Helididae															
Helix aspersa (Muller, 1774)	+	+	ˆ	-	+	-	+	-	-	-	-	-	+	-	-

key: - not found; + collected dead; * collected live; ˆ seen but not collected

Table 1. Species list within a tightly defined geographic region. Australian identifications by Neil E. Fahy using Smith & Kershaw (1979 & 1981). Some specimens were checked by Dr. Frank Climo, Curator of Mollusca, National Museum of New Zealand, Wellington.

Station	Locality (lot number)
	Melbourne
1	Yarra Glen (1652)
2	Fitzroy Gardens (1673)-1674)
3	Dandenong Ranges National Park, Fern Tree Gully track (1675-1677)
4	Dandenong Ranges National Park, Link Track (1678)
	Hobart
5	Queens Domain (1653-1654, 1712)
6	Princess Park (1655)
7	Wrest Point Federal Hotel & Casino (1671-1672)
8	Fern Tree Reserve, Silver Falls (1701)
9	Fern Tree Reserve, Reid Track (1702)
10	Mount Wellington Reserve (1703-1704)
11	Waterworks Reserve, Pipeline Track, viaduct (1705)
12	Waterworks Reserve, Pipeline Track, between reservoirs (1706-1707)
13	Waterworks Reserve, Pipeline Track, below Lower Reservoir (1708-1709)
14	Huonville (1710)
15	Mount Nelson (1711)

Table 2. Detailed locality list from tightly defined geographic region.

Land Snails collected in French Polynesia Species and locality list	French Polynesia		
	Bora Bora	Moorea	Tahiti
Helicinidae			
Orobophana pacifica (Pease, 1865)	+	+	-
Partulidae			
Partula rosea Broderip, 1832	-	+	-
Sublinidae			
Subulina octona (Bruguiere, 1792)	*	+	+
Achatinidae			
Achatina fulica (Bowdich, 1822)	*	+	+
Spiraxidae			
Euglandina rosea (Ferussac, 1821)	-	+	+
Edondontidae			
Martondontha boraborensis (Garrett, 1884)	+	-	-
Bradybaenidae			
Bradybaena similaris (Ferussac, 1821)	*	+	+

key: - not found; + collected dead; * collected live

Table 3. Species list defined by large geographic region.

	Victoria	Tasmania
Charopidae		
Elsothera ricei Brazier, 1871	-	+
Mulathena fordei (Brazier, 1871)	*	-
Zonitidae		
Oxychilus celarius (Müller, 1774)	+	+

Localities: Victoria - Dandenong National Park; Melbourne;
Yarra Glen
Tasmania - Hobart; Fern Tree Reserve;
Mt. Wellington Reserve

Table 4. Species list defined by large geographic region (state / province).

Australia, Neil Fahy	
Charopidae	
Elsothera ricei Brazier, 1871	101-91, 92;
Mulathena fordei (Brazier, 1871)	101-91;
Zonitidae	
Zxychilus cellarius (Müller, 1774)	101-91:

Table 5. Species-Collector-Date list

DISTRIBUTION OF MOLLUSKS IN THE NORTHEASTERN CHUKCHI SEA

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Infaunal and epifaunal mollusks of the northeastern Chukchi Sea were sampled. Range extensions and other biogeographical matters are discussed. The pattern of spatial distribution of each molluscan component was determined separately by classification and ordination techniques which resulted in six infaunal and five epifaunal station groups. Species characterizing various faunal groups are defined. Stepwise multiple discriminant analysis is applied to correlate animal associations with some measurements of environmental variables. Delineations of infaunal groups are mainly due to the percentage of sand present and bottom salinity, while epifaunal groups are separated by percent gravel and bottom temperature.

FOSSIL AND RECENT SPECIES OF EASTERN PACIFIC CYPRAEACEA (PEDICULARIIDAE, CYPRAEIDAE, AND OVULIDAE)

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Seventy-two species of fossil and Recent cypraeaceans are known from the eastern Pacific region and include the families Pediculariidae, Cypraeidae, and Ovulidae, following Ponder and Warén (1989); the oldest being from the Early Cretaceous.

A breakdown by geologic age yields eight Cretaceous species, four Paleocene species, 12 Eocene species, two Eocene/Oligocene species, six Miocene species, three Pliocene species, one Pleistocene species, and 36 Recent species. Ten of the Recent species are represented in the fossil record. The 36 Recent species include 21 endemic Californian/Panamic species and 15 Indo-Pacific species

The eastern Pacific region includes the earliest known cypraeid from the Western Hemisphere: *Palaeocypraea* (*Palaeocypraea*) *fontana* (Anderson, 1958) from the Lower Cretaceous Budden Canyon Formation, Yolo County, northern California and the earliest known ovulid from the Western Hemisphere: *Eocypraea* (*Eocypraea*) *louellae* Groves, 1990, from the Upper Cretaceous Yolo Formation, Yolo County, northern California.

Species of Fossil and Recent Cypraeacea of the Eastern Pacific

The citations that follow the original author indicate the first report of that living species in the fossil record.

[IP] = Indo-Pacific species

[Plio-Rec] or [Pleis-Rec] = Panamic species with fossil records

CRETACEOUS

Family Cypraeidae
Palaeocypraea (*Palaeocypraea*) *fontana* (Anderson, 1958)
Palaeocypraea (*Palaeocypraea*) *suciensis* (Whiteaves, 1895)
Bernaya (*Bernaya*) *crawfordcatei* Groves, 1990
Bernaya (*Protocypraea*) *argonautica* (Anderson, 1958)
Bernaya (*Protocypraea*) *berryessae* (Anderson, 1958)
Bernaya (*Protocypraea*) *gualalaensis* (Anderson, 1958)
Bernaya (*Protocypraea*) *rineyi* Groves, 1990
Family Ovulidae
Eocypraea (*Eocypraea*) *louellae* Groves, 1990

PALEOCENE

Family Cypraeidae
Propustularia kemperae (Nelson, 1925)
Propustularia simiensis (Nelson, 1925)
Family Ovulidae
Eocypraea (*Eocypraea*) *novasumma* (Nelson, 1925)
Sphaerocypraea martini (Dickerson, 1914)

EOCENE

Family Cypraeidae
Bernaya (*Bernaya*) *fresnoensis* (Anderson, 1905)
Bernaya (*Protocypraea*) *grovesi* Squires and Demetrion, 1992
Gisortia (*Megalocypraea*) *clarki* (Ingram, 1940)
Gisortia (*Megalocypraea*) *thomasi* (Olsson, 1930)
Family Ovulidae
Cyproglobina (*Luponovula*) *boggsi* (Olsson, 1928)
Eocypraea (*Eocypraea*) *bayerquei* (Gabb, 1864)
Eocypraea (*Eocypraea*) *castacensis* (Stewart, 1927)
Eocypraea (*Eocypraea*) *maniobraensis* Squires and Advocate, 1983
Sphaerocypraea negritensis (Olsson, 1928)
Sulcocypraea bullennewtoni (Olsson, 1930)
Sulcocypraea mathewsonii (Gabb, 1869)
Family Pediculariidae
Eucypraedia multicarinata chira (Olsson, 1931)

EOCENE/OLIGOCENE

Family Ovulidae
Sulcocypraea oakvillensis (van Winkle, 1918)

- Family Pediculariidae
  - *Cypraeogemmula warnerae* Effinger, 1938

MIOCENE

- Family Cypraeidae
  - *Barycypraea* (*Muracypraea*) *amandusi* (Hertlein and Jordan, 1927)
  - *Barycypraea* (*Muracypraea*) *angustirima* (Spieker, 1922)
  - *Barycypraea* (*Muracypraea*) *henekeni* (Gabb, 1873)
  - *Barycypraea* (*Muracypraea*) *projecta* (Ingram, 1947)
  - *Zonaria* (*Pseudozonaria*) *telembiensis* (Olsson, 1964)
- Family Ovulidae
  - *Sphaerocypraea keenae* (Woodring, 1959)

PLIOCENE

- Family Cypraeidae
  - *Barycypraea* (*Muracypraea*) *cayapa* (Pilsbry and Olsson, 1941)
  - *Luria chilensis* (Philippi, 1887)
- Family Ovulidae
  - *Cypropterina* (*Jenneria*) *panamensis* (Olsson, 1967)

PLEISTOCENE

- Family Cypraeidae
  - *Erosaria* (*Erosaria*) *cernica*? (Sowerby, 1870); (Kellogg, 1976) [IP]

RECENT

- Family Cypraeidae
  - *Blasicrura alisonae* (Burgess, 1983) [IP]
  - *Blasicrura teres* (Gmelin, 1791) [IP]
  - *Erosaria* (*Erosaria*) *albuginosa* (Gray, 1825); (Hertlein, 1957) [Plio-Rec]
  - *Erosaria* (*Erosaria*) *helvola* (Linnaeus, 1758) [IP]
  - *Erosaria* (*Ravitrona*) *caputserpentis* (Linnaeus, 1758) [IP]
  - *Erronea* (*Erronea*) *caurica* (Linnaeus, 1758) [IP]
  - *Luria isabellamexicana* (Stearns, 1893)
  - *Lyncina schilderorum* (Iredale, 1939) [IP]
  - *Lyncina vitellus* (Linnaeus, 1758) [IP]
  - *Macrocypraea cervinetta* (Kiener, 1843); (Dall and Ochsner, 1928) [Plio-Rec]
  - *Mauritia* (*Mauritia*) *depressa* (Gray, 1824) [IP]
  - *Mauritia* (*Mauritia*) *maculifera* Schilder, 1932 [IP]
  - *Mauritia* (*Mauritia*) *scurra* (Gmelin, 1791) [IP]
  - *Monetaria* (*Monetaria*) *moneta* (Linnaeus, 1758) [IP]
  - *Monetaria* (*Ornamentaria*) *annulus* (Linnaeus, 1758) [IP]
  - *Staphylaea staphylaea* (Linnaeus, 1758) [IP]
  - *Talparia talpa* (Linnaeus, 1758) [IP]
  - *Zonaria* (*Neobernaya*) *spadicea* (Swainson, 1823); (Arnold, 1903) [Plio-Rec]
  - *Zonaria* (*Pseudozonaria*) *arabicula* (Lamarck, 1810); (Grant and Gale, 1931) [Pleist-Rec]
  - *Zonaria* (*Pseudozonaria*) *nigropunctata* (Gray, 1828); (Hertlein, 1972) [Pleist-Rec]
  - *Zonaria* (*Pseudozonaria*) *robertsi* (Hidalgo, 1906)
  - *Zonaria* (*Zonaria*) *aequinoctialis* Schilder, 1933
  - *Zonaria* (*Zonaria*) *annettae* (Dall, 1909); (Dall, 1918) [Plio-Rec]
- Family Ovulidae
  - *Cyphoma emarginata* Sowerby, 1830
  - *Cypopterina* (*Jenneria*) *pustulata* (Lightfoot, 1786, ex Solander MS); (Palmer and Hertlein) [Pleis-Rec]
  - *Neosimnia aequalis* (Sowerby, 1832); (Peska, 1976) [Plio-Rec]
  - *Neosimnia avena* (Sowerby, 1832)
  - *Neosimnia bellamaris* Berry, 1946
  - *Phenacovolva lenoreae* Cardin and Walls, 1980
  - *Pseudocypraea adamsonii* (Sowerby, 1832) [IP]
  - *Simnialena macleani* (Cate, 1976)
  - *Simnialena rufa* (Sowerby, 1832)
  - *Spiculata barbarensis* (Dall, 1892); (Willett, 1937) [Pleis-Rec]
  - *Spiculata loebbeckeana* (Weinkauff, 1881)
  - *Xandarovula hammesi* Bertsch and Bibbey, 1982
- Family Pediculariidae
  - *Pediculariella californica* (Newcomb, 1864); (Groves, 1992) [Pleist-Rec]

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MODIOLUS CAPAX, A DISTRESSED BIVALVE AT BAHÍA DE LOS ANGELES, BAJA CALIFORNIA, MEXICO

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During late 1989 and early 1990, I made several field trips to the Gulf of California, and observed that populations of the mussel, *Modiolus capax* (Conrad, 1837), were dying. Seemingly sick mussels displayed their orange mantle, inner gills and adductor muscle. Tapping on the bivalve did not stimulate closure of the shell. Specimens were collected, examined by Dr. Cosgrove (formerly of the San Diego Zoo), and Dr. Harshbarger (Tumor Registry of Invertebrates, Smithsonian Institution). Although necrotic tissue was found, no lesions nor cause for their illness could be determined.

Other species of marine mollusks have been damaged by muscle wasting disease (a coccidean parasite affects the foot muscle of black abalone in California's Channel Islands), dinoflagellate poisoning (mussel beds in Ireland), and domoic acid from diatoms (affecting "shellfish" in Monterey Bay, California).

AN OVERVIEW OF THE FAMILY CAECIDAE IN THE PACIFIC AND INDIAN OCEANS

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The Eastern Pacific has two genera with five subgenera. In the north the genus *Caecum* has *Caecum s.s.* with two species, and *Micranellum* with one species, and *Fartulum* with one subgenus, *Fartulum s.s.* having two species. One species of each genus extends as far north as Alaska.

In the Panamic Province *Caecum* has three subgenera, *Caecum s.s.* with several species, *Micranellum* with two species, *Elephantunellum* with two good species. *Fartulum* has two subgenera, *Fartulum s.s.* with several species, and *Elephantulum* with at least one species.

None of the species mentioned above from the Eastern Pacific are found in the Western Pacific or Indian Oceans. Several species found farther south in Peru and Chile are found only there or in the Atlantic.

In the Indo-Pacific *Caecum* has three subgenera, *Caecum s.s.* with about twelve species, *Brochina* with two species, and *Micranellum* with one. *Pictocaecum* is single species genus. *Fartulum* has several small species. *Meioceras* has two species. *Strebloceras* has only one species. *Parastrophia* has at least two plus another undescribed species. The specimens used for this study were from the Los Angeles County Museum and private collections.

CATEGORICAL RANK IN OPISTHOBRANCH GASTROPODA: WHAT, IF ANYTHING, DOES IT TELL US?

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According to the ideals of evolutionary systematics the arrangement of groups reflects phylogeny and the rank expresses the amount of difference between them. If this be so, then taxa of the same rank can be legitimately equated as the same kind of units in a given process, such as extinction.

A historical review shows other criteria of rank. Taxa are given the same rank if diagnosed on the same basis, for example, Prosobranchia, Opisthobranchia, and Pulmonata. Rank of groups in general has been elevated. Splitting of groups deemed artificial has raised the rank of their components, such as the two orders of pteropods. A high rank for some groups, such as Philinoglossacea, is a euphemism for *incertae sedis*. Runcinacea is treated as an order in spite of its genealogical position within the order Cephalaspidea, because it has an extra plate in its gizzard. The "porostome" nudibranchs are removed from the Cryptobranchia, concealing their relationship, because the diagnostic gills have been lost in some of them.

Whatever the ideals for ranking may be, actual practice is largely a matter of rhetoric, tradition, and ignorance.

JAPANESE CONTRIBUTIONS TO OPISTHOBRANCH RESEARCH, WITH SPECIAL REFERENCE TO TAKEO ABE, IWAO HAMATANI, AND KIKUTARO BABA

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Several years ago, in the foreword to David Behrens' first edition of *Pacific Coast Nudibranchs*, I summarized the history of opisthobranch research along the Pacific Coast of the United States and Canada (Bertsch, 1980). This paper continues my studies on the history of opisthobranch investigation. It is a bio-bibliography of research on nudibranchs in the western Pacific Ocean by Japanese scientists. My emphasis is on the contributions by Japanese citizens to our knowledge of Opisthobranchia.

In 1971 Henry D. Russell published *Index Nudibranchia: a Catalogue of the Literature, 1554-1965*. He listed 176 species and subspecies of nudibranchs that were named from Japan. Of these, 130 species (almost 75%) were named by Kikutaro Baba; the rest were named by various European, Russian, or American investigators, such as Arthur Adams, L.S.R. Bergh, Charles Eliot, Cuthbert Collingwood, N. I. Volodchencko, Nils Odhner, William Stimpson, and Cesare Tapparone-Canefri. The important contribution of Japanese researchers to our understanding of the Japanese fauna cannot be overemphasized. Speaking comparatively, they have published a proportionately higher number of new species names for their region than have investigators living along the Pacific Coast of the United States and Canada.

The majority of these contributions have been made by three men: Takeo Abe, Iwao Hamatani, and of course, Kikutaro Baba. I hope that this historical study will show Dr. Baba and his colleague Mr. Hamatani, the high degree of respect that we have for their significant contributions to our knowledge of opisthobranch molluscs.

PART I

Before I discuss these 3 scholars, let me summarize the contributions of other Japanese investigators. These consist of one or several papers by individual authors, often on a specific biochemical or biological topic.

Kohman Y. Arakawa (1960, 1962) published 2 brief miscellaneous notes, emphasizing mating and spawning habits of Japanese molluscs. Tsunenobu Fujita (1892) published 5 articles in the *Zoological Magazine* on cryptobranchiate molluscs from Misaki, Japan.

Between 1959 and 1967, Akihiko Inaba published several cytological studies on the chromosomes of nudibranchs; several of these papers were coauthored by R. Hirota or Yasuko Saiki.

Kojiro Kato (1949) published on *Kaloplocamus ramosus*, and S. Kawaguti (1943) discussed zooxanthellae occurrence within *Phestilla sibogae* (= *P. lugubris*).

Y. Komai and co-authors (1971) described glycolipids in nervous tissue. Seiichi Komori (1932) wrote, "Origin of the eolidian nematocysts from the standpoint of regeneration," in the *Annotationes Zoologicae Japonenses*. Shigeki Matsunaga *et al.* (1986) elaborated the chemical structure of kabiramide C, an antifungal compound found in nudibranch egg masses. In 1967, A. Nakamura used electron microscopy to describe the cerata of *Godiva ceylonica*.

Toshio Ohuyo (1938) wrote about the histological properties of body fluids. In 1928 and 1934 Yaichiro Okada was the senior author of two papers with a young Kikutaro Baba on the bioluminescence of *Plocamopherus tilesii*. Hiroshi Oshima (1933) identified pycnogonid ectoparasites on nudibranchs.

Takasi Tokioka (1952 and 1963) published 2 articles on *Fiona pinnata* and Chilean specimens of *Cephalopyge trematoides*.

The most fascinating title belongs to Shiro Tsuchiya. In 1928 he published, "Ueber den Bau der Spermatozoen von *Limax* und *Doris*, mit besonderer Rucksickt auf den Verergbungsstoff des Protoplasmas."

Itaru Usuki (1967 and 1969) described direct development in a chromodorid nudibranch and the opisthobranch fauna in the Sado district of the Japan Sea.

K. Yamaguchi (1971) wrote about biliproteins in the Bulletin of the Japanese Society of Scientific Fisheries.

The bibliographic citations for these articles are:

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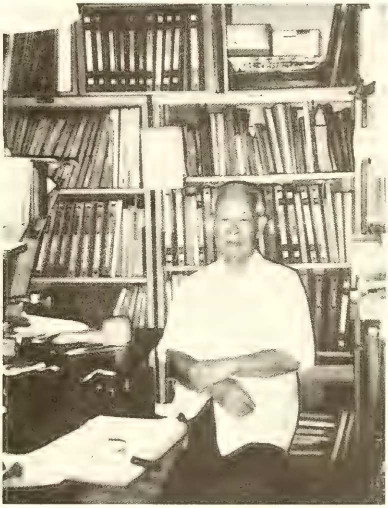
PART II

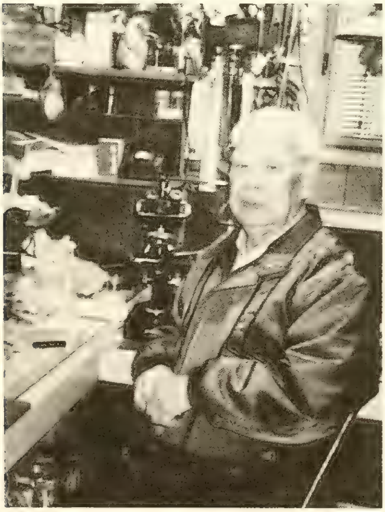
Although numerous individuals have been studying aspects of opisthobranch mollusc biology in Japan, the major contributions have been made (as I stated earlier) by three men: Takeo Abe, Iwao Hamatani, and Kikutaro Baba.

Takeo Abe was born 5 December 1909, in Shinminato City, Toyama Prefecture, Japan. He was graduated from Fukuno High School of Agriculture in March 1927, and the following year (June 1928) became a teacher at Toyama High School. In September 1946 he started teaching at Takaoka High School, and became an advisor of the Biological Club of Takaoka High School. Haruo Izumi (one of Mr. Abe's former students) is now manager of this club.

In April 1950, Takeo Abe began studying nudibranchs, co-authoring various papers with K. Baba. He published (1964) "Opisthobranchia of Toyama Bay and Adjacent Waters." Mr. Abe died of cancer on 14 February 1978, at the age of 68.

Explanation to Figures on Facing Page: Top left, Iwao Hamatani in the laboratory of the R/V Sohgen-Maru, August 1990. **Top right**, Kikutaro Baba at Mt. Shigi-san Temple Yard, 4 April 1992. **Center left**, Kikutaro Baba and his wife, Sinoko Baba, at home, 10 October 1985. **Center right**, Kikutaro Baba seated at his desk in his Shigi-ga-ok Hill Room laboratory, 20 July 1990. **Bottom left**, Kikutaro Baba at the microscope in his laboratory, 26 April 1992. **Bottom right**, Kikutaro Baba collecting at the shore of Mukaishima Marine Biological Station, Hiyoshima University, Seto Inland Sea, 20 April 1989.





Iwao Hamatani was born 14 November 1930, in Tokyou, Japan. He was graduated from the Osaka Kyouiku University, Osaka, Japan, in March 1953, with a Bachelor of Education and Science. Between 1962 and 1989 he was a biology teacher at the Senior High School of Osaka Kyouiku University. Mr. Hamatani has published 73 technical papers, of which 40 appeared in the Japanese language. He shared more than fifteen publications with Dr. Baba, as junior author. He has published on the developmental biology and anatomy of numerous species of opisthobranchs, on the adult morphology of eolid nudibranchs (including *Embletonia gracilis*, *Favorinus japonicus*, and *Sakuraeolis enosimensis*), and on various sacoglossan and notaspidean species. His most recent publication (1991) described a new genus and species of sacoglossan, *Sohgenia palauensis*.

Dr. Kikutaro Baba has almost single-handedly described the biodiversity of the Japanese opisthobranch fauna. Nearly 3/4's of the species recorded by Russell (1971) were named by Dr. Baba. A measure of the esteem in which he is held is shown by the patronyms he holds: 3 genera (*Babaina* Odhner, 1968, *Babakina* Roller, 1973, and *Babaiella* Risso-Dominguez, 1964) and 8 species of opisthobranchs have been named for him (*Linguella babai* Tchang-Si, 1934, *Marionopsis babai* Odhner, 1936, *Elysia babai* Pruvot-Fol, 1946, *Okenia babai* Hamatani, 1961, *Tamanovalva babai* Burn, 1965, *Flabellina babai* Schmekel, 1970, *Cyerce kikutarobabai* Hamatani, 1976, *Chelidonura babai* Gosliner, 1988).

The Emperor of Japan and Dr. Baba collaborated on two major works: *The Opisthobranchia of Sagami Bay* (1949) and *Supplement to Opisthobranchia of Sagami Bay* (1955). Careful anatomical dissection and descriptions of the living organisms make these two works classics in the field of opisthobranch research. The Emperor collected most of the organisms on which Dr. Baba reported.

Dr. Baba has published segments in 19 books in Japanese, more than 50 miscellaneous notes and papers in Japanese, 55 articles in the Japanese aquarist magazine *Collecting and Breeding*, and more than 120 papers in English. Clearly, his contributions to opisthobranch studies are monumental. Comparisons of the significance of his research must be made with Ludwig S. R. Bergh and Ernst and Eveline Marcus. However, whereas these researchers emphasized shapeless and colorless preserved specimens, Dr. Baba has always studied living specimens before dissecting their internal anatomical structure. This is essential to understand the morphological variation and anatomical characteristics of opisthobranch molluscs.

Kikutaro Baba was born 11 July 1905 in Fukuoka Prefecture, Kyushi, Japan. In 1932 he was graduated from the Biology Department of the Tokyo Bunrika University. In 1940 he earned the degree of Rigaku-Hakushi (Dr. Sci.) from the Kyoto Imperial University. His dissertation was on the mechanisms of absorption and excretion in the solenogaster *Epimenia verrucosa* (Nierstrasz). From 1941 to 1943 he was a member of the Research Institute for Natural Resources attached to the Education Ministry, and from 1943 to 1947 he served as Military Government Professor of Zoology in the Jakarta Medical College, Java. He was a member of the Science Education Office, at Osaka Prefecture, from 1947-1948, and Professor of Biology in the Osaka First Normal School (1948-1949). Dr. Baba held the position of Professor of Biology at Osaka Kyoiku University from 1949 to 1971, and is now Professor Emeritus.

In 1976 he received the Third Class of Merit of the name of His Majesty the Emperor of Japan. He became an honorary member of the Japanese Society of Systematic Zoology in 1987, and the Malacological Society of Japan in 1988. It is my extreme pleasure to report that he was named an honorary member of the Western Society of Malacologists in 1992.

Iwao Hamatani and Kikutaro Baba have most graciously sent me photographs of themselves. Several of these photographs accompany this article. When Dr. Baba mailed me a photograph of himself and his wife, he wrote: "This is to respond to your requests just received. Of late years I have been mostly in my home to conclude my past studies, so I could not give you my latest pictures in the field (also my picture on shore in Sagami Bay). Only a few pictures are enclosed here. My wife, Mrs. Sonoko Baba, is well, and helps me in various ways." Since he wrote that letter, Dr. Baba kindly sent me more photographs.

Following are the bibliographic citations for the complete works of Takeo Abe, Iwao Hamatani, and Kikutaro Baba (provided by Mr. Hamatani and Dr. Baba in May 1992). Please note that most of Dr. Baba's publications have been arranged under several general headings (works or books in Japanese, English articles, etc.), and that this complete bibliographic list of his publications also includes several non-molluscan and non-opisthobranch references.

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1977. A new species tentatively referred to *Antonietta*, *Antonietta janthina*, from Japan (Nudibranchia: Eolidoidea: Facelinidae). Veliger 20 (1): 9-13. (K. Baba & I. Hamatani)

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1980. Kyocho gendai seibutsu gakko taibe. 11 a. Hase to bunka. A, 3 Soshiki bunkato kikan kese. II. Haihase, 6 Nantai Dobutsu Nakayama Shoten. [in Japanese]

1980. Maki kaiyuo mota nu maki gai no hakama umiushi Dobutsu Toshizen To Kushnu 10 (7), Kaino kurashi: pp. 10-14. [in Japanese]

1980. On the species of the genus *Oxynoe* Rafinesque, 1819, from Japan, inclusive of a new species (Opisthobranchia: Ascoglossa). Publ. Seto Mar. Biol. Lab. 25 (5/6): 349-360.

1983. Book Review. Kaiyoto Seibutsu (Marine Biology) 5 (5): 352. [in Japanese]

1983. *Pseudovermis japonicus* Hamatani & Nonomura, 1973. Kaiyoto Seibutsu (Marine Biology) 5 (6). [in Japanese]

1983. Yamamoto torao parao. Saishu Seibutsu 25 (2): 218-219. [in Japanese]

1983, 1984, 1986 a, 1986 b. Four Japanese references (Hamatani numbers 66, 69, 70, and 71); unable to transliterate or translate

1986. *Oxynoe kabirensis* Hamatani, 1980. Kaiyoto Seibutsu (Marine Biology) 8 (8).

ACKNOWLEDGEMENTS

I am grateful to Iwao Hamatani and Dr. Kikutaro Baba for their generous reponses to my requests for information; I also thank Debra (Ai) Okamoto, Rihoko Ponder, and Yumi Alhamdan for assistance with transliteration or translation of various Japanese references.

OPISTHOBRANCH MOLLUSKS OF PERU

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Opisthobranchs collected in Peru by the author and from the collection of Dr. Carlos Paredes, Universidad National Mayor de San Marcos, Lima, and from Nelly Vargas and Aldo Indacochea, Universidad Richardo Palms, Lima, were examined. Specimens were from two areas, Talara in the north of Peru and within a 200 km radius of Lima in the southern half of Peru. Slides of the animals and scanning electron micrographs of their radulas are shown. Range extensions of known species are discussed. Emphasis is placed on the internal anatomy of the little known bubble snail *Haminoea peruviana* Orbigny, 1837.

EFFECTS OF SEASONALITY ON THE ECOLOGY AND COMMUNITY STRUCTURE OF OPISTHOBRANCHS FROM THE CENTRAL GULF OF CALIFORNIA

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California State University
Northridge, California, USA

There has been considerable ecological research on opisthobranch mollusks owing in part to their global distribution, habitat heterogeneity and high species diversity. Biogeography and natural history compose the majority of these ecological papers. It would appear that the community level of opisthobranch research has been, to some extent, neglected. Nearly two years of data obtained from an opisthobranch community inhabiting a shallow nearshore reef in the central Gulf of California constitutes the basis for this paper. Three distinct reef zones were sampled, noting species present, abundance, body length, microhabitat preference and activity. These will be looked at in relation to depth and seasonality. A partial analysis of these data will be summarized, suggesting a complex mixture of organisms residing in a highly varying environment.

DORID NUDIBRANCH FORAGING ECOLOGY IN THE GIANT KELP FOREST

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Because all organisms require food to survive and reproduce, feeding efficiency should be an important component to fitness. I seek to answer the question: What are the effects of feeding on causes of the distribution and abundance of dorid nudibranchs in kelp forests in Monterey Bay. I focused on Doridacean nudibranchs which primarily eat sponge. The species are: *Anisodoris nobilis* MacFarland, 1905, *Diaulula sandiegensis* (Cooper, 1863), *Doriopsilla albopunctata* (Cooper, 1863), *Cadlina flavomaculata* MacFarland, 1905, and *Cadlina luteomarginata* MacFarland, 1966. Distributions of these nudibranchs within their subtidal habitat may be accounted for by many factors including different food preferences, or by different distributions of prey. Field observations from monthly transects were carried out for two years, 100 m offshore from Hopkins Marine Station (36° 37' N; 121° 54' W) at the south end of Monterey Bay, California. I compared my field observations of species composition, and abundance of nudibranchs and sponges, as well as feeding preferences, with lab observations. These observations include ranking the sponge species in manipulative experiments for food preference, at the Monterey Bay Aquarium's Kelp Forest Exhibit, and measuring the total digestible energy content of sponge with Carbon Hydrogen Nitrogen analysis.

THREE PACIFIC OCEAN *APLYSIA* SPECIES OF THE CALIFORNIAS

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San Diego, California, USA

The anatomy *of Aplysia californica, A. cedrosensis,* and *A. vaccaria* will be compared. Field work areas include Bahía de los Angeles (in the Gulf of California), Cabo Colnett (Pacific coast of Baja California), and southern California.

1993 Annual Meeting

The 1993 Western Society of Malacologists Annual Meeting will be held at the Radisson Hotel in La Jolla, California (north of San Diego). Meeting dates will be from Sunday, 27 June to Thursday, 1 July. For further information please contact the 1993 WSM President, Douglas Eernisse, or Henry Chaney.

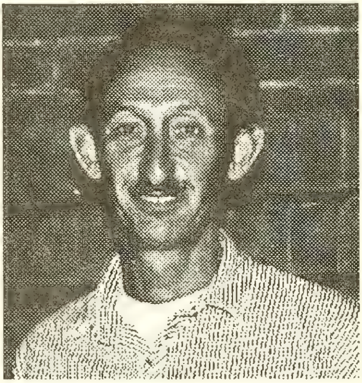
1994 Annual Meeting - First Notice

The 1994 Western Society of Malacologists Annual Meeting will be held in Santa Barbara, California. Meeting dates will be from 26-30 June. For further information please contact the 1994 WSM President, Kirstie Kaiser, or Treasurer Henry Chaney.

1992 WESTERN SOCIETY OF MALACOLOGISTS AWARD OF HONOR PRESENTED TO DR. EUGENE V. COAN

Judith Terry Smith
Mitchell Building 101
Stanford University
Stanford, California 94305

"Article X of the bylaws of the Western Society of Malacology established an Award of Honor to be conferred in recognition of outstanding accomplishments or contributions in the fields of Conchology and Malacology." Eugene V. Coan of Palo Alto, California, has earned this honor through his scholarship, publications, and service to the Society, to west coast malacology, and our science in general.



He has served the WSM as President (1971), banquet speaker (1969), member of the Executive and Editorial Boards, Mentor-Parliamentarian, and is a consistent contributor to technical sessions. A member of the Student Grant Committee since its beginning in 1972, he is continuing now that the Committee has shifted to southern California. Other professional appointments include co-editor of *Malacologia* and member of the Executive Board of the *Veliger*. He is a Research Associate of the California Academy of Sciences, the Los Angeles County Museum of Natural History, and the Santa Barbara Museum of Natural History. Gene was co-convener, with Paul Scott and Brian Morton, for the Bivalve Symposium at the AMU/WSM meeting in Berkeley in 1991. For 20 years he marshaled San Francisco Bay Area malacologists for a day-long gathering for informal talks and show and tell (these early spring meetings are now organized by Matt James of Cal State Sonoma). Long interested in Latin American malacology, Gene worked to initiate the First Latin American Malacological Congress in Caracas, Venezuela in 1991 and with Melbourne Carriker and Donald Moore, set up a system to facilitate communications between Latin American and North American institutions.

Gene's publications reflect his meticulous attention to details, especially in taxonomy and in synthesizing and organizing massive amounts of information. He has written profiles and scientific bibliographies on, among others, Philip Carpenter, J.G. Cooper, Henry Hemphill, Josiah Keep, Ida Shepard and Tom Oldroyd, and his advisor, mentor and friend, A. Myra Keen, with whom he co-authored "Marine Molluscan Genera of Western North America," 2d edition (1974). He has published systematic reviews of bivalve families and contributed substantially to Keen's "Seashells of Tropical West America," 2d edition (1971) and "Light's Manual: Intertidal Invertebrates of the Central California Coast," 3d edition (1975), edited by Ralph I. Smith and James T. Carlton. With Paul Scott, he is currently at work on an exhaustive volume begun by Frank Bernard on the bivalve mollusks of the northeastern Pacific Ocean.

Like Philip Carpenter in the 1800's, and many colleagues today, Gene accomplishes his malacological research apart from his regular job, currently Director of National Volunteer Services for the Sierra Club in San Francisco. Formerly an Assistant Conservation Director, he has delivered testimonies to House and Senate Committees on biological diversity, waste disposal, and oil pollution, among other subjects. He was also co-editor of several editions of the World Directory of Environmental Organizations published by the Sierra Club.

Gene's university training took place at Los Angeles City College, the University of California, Santa Barbara (BA 1964), and Stanford University (Ph.D. 1969), where he was a student of A. Myra Keen; he also spent several seasons at Hopkins Marine Station. His doctoral dissertation focused on "Taxonomic studies on the Tellinacean bivalve mollusks of the northeastern Pacific." In appreciation of collaboration and friendship, colleagues have named several molluscan taxa for him including *Tellina coani* Keen, 1971, *Choristes coani* Marincovich, 1977, *Halistyhes genecoani* McLean, 1984, and *Limatula coani* Bernard, 1988.

The Western Society of Malacologists Award of Honor recognizes his many contributions, remarkable energy and organization, and help to amateurs and professionals alike. A bibliography through fall, 1992, follows:

Coan Molluscan Bibliography

[Note: This does not include the very large number of items edited for the Sierra Club, including mailers, reports, pamphlets, and booklets, nor minor things written for the Club, including hundreds of short articles. A few booklets, pamphlets, and articles that are more formal are included, however.]

1961

The shell voyagers of Anacapa. Assoc. Shell Clubs of Calif., News 2(1): 3 (1 July)

The literary conchologist. Shells and their Neighbors 8: 6-7 (Dec.)

1962

Topolobampo and Altata. Assoc. Shell Clubs of Calif., News 2(4): 68 (1 April)

Shell towns. Shells and their Neighbors 11: 8 (June)

Report from Stanford. Assoc. Shell Clubs of Calif., News 3(2): 34 (1 Oct.)

Museum collections, no. 1: The Los Angeles County Museum. Assoc. Shell Clubs of Calif., News 3(2): 36 (1 Oct.)

Notes on some tropical West American mollusks. The Veliger 5(2): 92 (1 Oct.)

A few notes on the intertidal zonation of the West Mexican coast. Amer. Malac. Union, Ann. Repts. for 1962 [Bull. 29]: 28 (1 Dec.) [abst.]

1963

Wrong-way Coan [first part]. Western Assoc. Shell Clubs, News 4(1): S3-S4 (1 Jan.)

Marine molluscan genera of western North America: an illustrated key. Stanford, Calif. (Stanford Univ.) 126 pp. (14 Jan.) (A. Myra Keen, with the assistance of Eugene Coan)

Wrong-way Coan [second part]. Western Assoc. Shell Clubs, News 4(2): S7-S8 (1 March)

Mollusca of Santa Barbara County. Amer. Malac. Union, Ann. Rept. for 1963 [Bull. 30]: 35 (1 Dec.) [abst.]

1964

A proposed revision of the Rissoacean families Rissoidae, Rissoinidae, and Cingulopsidae (Mollusca: Gastropoda). The Veliger 6(3): 164-171 (1 Jan.)

A note on the natural history of *Pleurobranchaea* spec. (Gastropoda: Opisthobranchia). The Veliger 6(3): 173 (1 Jan.)

The Mollusca of the Santa Barbara County area. Part I – Pelecypoda and Scaphopoda. The Veliger 7(1): 29-33 (1 July) [Pt. II not published; see 1966 below]

Biometrical analysis of Mollusca, Bahia de los Angeles, Baja California, Mexico. Amer. Malac. Union, Ann. Rept. for 1964 [Bull. 31]: 48 (1 Dec.) [abst.]

1965

A proposed reclassification of the family Marginellidae (Mollusca: Gastropoda). The Veliger 7(3): 184-194 (1 Jan.)

Kitchen midden mollusks of San Luis Gonzaga Bay. The Veliger 7(4): 216-218; pl. 28 (1 April) [reprint of the above: Katunob (Newsletter-Bulletin on Mesoamerican Anthropology) 6(4): 42-45 [without pl.] (July 1969)]

Generic units in the Heteropoda. The Veliger 8(1): 36-41 (1 July)

A new species of *Persicula* from West Mexico. The Veliger 8 (2): 67-69; pl. 12 (1 Oct.) (... & Barry Roth)

Analysis of marine shelled organisms, In: Roger C. Owen, Freddie Curtis, & Donald S. Miller, "The Glen Annie Canyon Site, SBa 142: an early horizon coastal site of Santa Barbara County." Univ. Calif. at Los Angeles, Dept. Anthro., Archeo. Surv., Ann. Rept. for 1963-1964: 462-465, 495 (15 Nov.) (William L. Garrison, Jr., & Gene Coan)

Toward greater order: Procedure in revising a molluscan family. Amer. Malac. Union, Bull. for 1965 [Bull. 32]: 48 (1 Dec.) [abst.]

1966

Voluta mitra Linnaeus, 1758, vs. *Voluta episcopalis* Linnaeus, 1758 (Mollusca: Gastropoda): proposed use of Plenary Powers. Z.N.(S.) 1728. Bull. Zool. Nomencl. 22(5/6): 355-356 (31 Jan.) [see Opinion 885, 24 Oct. 1969]

The West American Marginellidae. The Veliger 8(4): 276-299; pls. 48-51 (1 April) (... & Barry Roth)

Concerning "The Mollusca of the Santa Barbara County Area. Part II. Gastropoda and Amphineura." The Veliger 8(4): 313 (1 April)

Concerning the Stanford University set of Mollusca from the Branner-Agassiz Expedition to Brazil. The Veliger 8(4): 313-314 (1 April)

Charles Russell Orcutt, pioneer Californian malacologist, and *The West American Scientist*. San Diego Soc. Natur. Hist., Trans. 14(8): 85-96; 1 pl. (29 April)

Nomenclatural units in the gastropod family Mitridae. The Veliger 9(2): 127-137 (1 Oct.)

The story of the West American Marginellidae. Amer. Malac. Union, Ann. Rept. for 1966 [Bull. 33]: 73 (1 Dec.) [abst.] (... & Barry Roth)

1968

Some thoughts on the West American Tellinacea. Amer. Malac. Union, Ann. Rept. for 1967 [Bull. 34]: 74 (20 March) [abst.]

Further observations on the West American Marginellidae, with the descriptions of two new species. The Veliger 11(1): 62-69; pl. 7 (1 July) (Barry Roth & ...)

A biological survey of Bahia de los Angeles, Gulf of California, Mexico. III. Benthic Mollusca. San Diego Soc. Natur. Hist., Trans. 15(8): 108-132 (25 Sept.)

A new species of the genus *Macoma* (Pelecypoda) from West American coastal waters, with comments on *Macoma calcarea* (Gmelin 1791). Nation. Mus. Canada, Natur. Hist. Pap. 43: 19 pp. (9 Dec.) (Robert M. Dunnill & ...)

1969

Recognition of an eastern Pacific *Macoma* in the Coralline Crag of England and its biogeographic significance. The Veliger 11(3): 277-279 (1 Jan.)

What is *Macoma truncaria* Dall? The Veliger 11(3): 281-282 (1 Jan.)

Tellina obliqua J. Sowerby, 1817 (Bivalvia): proposed conservation under the Plenary Powers. Z.N.(S.) 1849. Bull. Zool. Nomencl. 25(4/5): 166 (17 Jan.) (... & D. L. F. Sealy) [see Opinion 948, 29 March 1971]

The present state of west American marine molluscan systematics. Western Soc. Malac., The Echo 1: 8 (20 March)

The biogeography of certain west American tellinaceans. Western Soc. Malac., The Echo 1: 11-12 (20 March)

Reprint of: "Kitchen midden mollusks of San Luis Gonzaga Bay." Katunob (Newsletter-Bulletin on Mesoamerican Anthropology) 6(4): 42-45 [without pl.] (July)

Realia Baird, 1850 (Gastropoda): request for suppression under the Plenary Powers. Z.N.(S.) 1878. Bull. Zool. Nomencl. 26(2): 99-104 (8 Aug.) (Myra Keen & ...) [see Opinion 973, 31 Dec. 1971]

A bibliography of the biological writings of Philip Pearsall Carpenter. The Veliger 12(2): 222-225 (1 Oct.)

Taxonomic studies on the tellinacean bivalve mollusks of the northeastern Pacific. Disser. Abst. Intl. 30(4) (B. The Sciences & Engineering): 1953B (Oct.)

1970

Keeping up with the past. Western Soc. Malac., The Echo 2: 27 (9 March)

Philip Pearsall Carpenter, a man for our times. Western Soc. Malac., The Echo 2: 40-45 (9 March) [a banquet talk reproduced almost in its entirety, but without the quotations from Carpenter used in the talk]

The date of publication of Gould's "Descriptions of Shells from the Gulf of California." The Veliger 13(1): 109 (1 July)

1971

New information on the subfamilies of the Marginellidae. Western Soc. Malac., The Echo 3: 21 (7 March) [abst.]

The northwest American Tellinidae. The Veliger 14(Suppl.): 63 pp.; 12 pls. (15 July)

Marginellidae (Mollusca: Neogastropoda) from the Galapagos Islands and Cocos Island. Calif. Acad. Sci., Proc. (4)37(23): 575-584 (23 Nov.) (Barry Roth & ...)

Report on marine conservation programs. Western Soc. Malac., The Echo 4: 17-18 (27 Dec.) [abst.]

1972

The international role of the Sierra Club: A proposal. Sierra Club Bull. 57(1): 12-14 (Jan.)

The Sierra Club Political Handbook, 1st ed. San Francisco, Calif. (Sierra Club) 31 pp. (1 Feb.)

What's the difference?: authorship of a taxon. The Veliger 15(1): 64-65 (1 July)

1973

Family Marginellidae. Pp. 5-6 in: A Myra Keen, "Suggested generic allocations for some Japanese molluscan species." Tohoku Univ., Sci. Rept. (2)(Geol.), Spec. Vol. 6: 1-6 (25 Feb.) (... & Barry Roth)

The scallop fishery at Bahia de los Angeles. Western Soc. Malac., Echo 5: 24 (5 March)

A report on the rare and endangered species of West American land snails. Western Soc. Malac., Echo 5: 24-25 (5 March) [abst.] (... & Barry Roth)

The northwest American Semelidae. The Veliger 15(4): 314-329; 2 pls. (1 April)

The northwest American Psammobiidae. The Veliger 16( ): 40- 57; 4 pls. (1 July)

The northwest American Donacidae. The Veliger 16(2): 130-139; 1 pl. (1 Oct.)

Differentiation: the meaning of ICZN Article 13(a)(i). The Veliger 16(2): 243-245 (1 Oct.)

1974

Strategies for international environmental action: The case for an environmentally oriented foreign policy. Natur. Res. Journ. 14(1): 87-102 (Jan.) (..., Julia Hillis, & Michael McCloskey)

Progress in protecting the marine environment. Western Soc. Malac., Echo 6: 59-62 (Feb.)

Marine molluscan genera of western North America: An illustrated key, 2nd ed. Stanford, Calif. (Stanford Univ.) 208 pp. (2 May) (Myra Keen & ...)

Is there double trouble in marsupial clams? The Veliger 17(2): 183-184; 1 pl. (1 Oct.)

Is there double trouble in marsupial clams? Western Soc. Malac., Ann. Rept. 7: 16 (12 Nov.) [abst.]

Progress in protecting the marine environment, 1974. Western Soc. Malac., Ann. Rept. 7: 34-35 (12 Nov.)

1975

Phylum Mollusca: Bivalvia. pp. 543-578; pls. 124-132, in: Ralph I. Smith & James T. Carlton, eds., "Light's Manual: Intertidal Invertebrates of the Central California Coast." (?10 March) (... & James T. Carlton)

[Review of] "Papers on the Sowerby family." The Veliger 18(1): 106-107 (1 July)

"Sea Shells of Tropical West America": Additions and Corrections to 1975. Western Soc. Malac., Occ. Paper 1: 66 pp. (22 June) (Myra Keen & ...)

Notice concerning Occasional Paper 1 of the Western Society of Malacologists. Western Soc. Malac., Ann. Rept. 8: 5-6 (1 Nov.) [unsigned; has some "additions and corrections"]

1976

The availability of taxa proposed in the *Minutes of the Conchological Club of Southern California*. The Veliger 18(3): 326-331 (1 Jan.)

Amer. Malac. Union, Bull. for 1975 [41]: 96 pp. (30 Jan.) (Eugene V. Coan & Dee S. Dundee, co-editors)

The availability of taxa proposed in the *Minutes of the Conchological Club of Southern California*. Amer. Malac. Union, Bull. for 1975 [41]: 71 (30 Jan.) [abst.]

A catalogue of collations of works of malacological importance. Western Soc. Malac., Occ. Paper 2 : 34 pp. (17 Aug.) (George E. Radwin & ...)

A preliminary survey of the northwest American Carditidae. Western Soc. Malac., Ann. Rept. 9: 47 (12 Oct.) [abst.]

Status of the genus *Hyalina* Schumacher, 1817 (Mollusca: Gastropoda). Journ. Moll. Stud. 42(2): 217-222 (Oct.) [... & Barry Roth]

1977

Preliminary review of the northwest American Carditidae. The Veliger 19(4): 375-386; 4 pls. (1 April)

Glans carpenteri vs. *Glans subquadrata*: the rules concerning renamed transient second homonyms. The Veliger 20(1): 63 (1 July)

Comments on three west American bivalve nomenclatural problems. Western Soc. Malac., Ann. Rept. 10: 9 (14 Dec.)

1978

Nomenclatural notes on *Hinnites giganteus* (Gray). The Veliger 20(3): 297-298 (1 Jan.) (Barry Roth & ...)

1979

A review of the west American species of the genus *Crassinella*. Western Soc. Malac., Ann. Rept. 10: 9 (9 Jan.) [abst.]

The life and times of James Graham Cooper; or, back and forth in America. Western Soc. Malac., Ann. Rept. 10: 14 (9 Jan.) [abst.]

Conserving our natural heritage: The Sierra Club. Pp. 495-500, in: Peter B. Kaufman & J. Donald LaCroix, "Plants, People, and Environment." New York, NY (Macmillan) 576 pp. (27 Feb.)

Recent eastern Pacific species of the crassatellid bivalve genus *Crassinella*. The Veliger 22(1): 1-11; 4 pls. (1 July)

1980

Nettastomella Carpenter, 1865 (Mollusca: Bivalvia: Pholadidae): proposed conservation under the Plenary Powers. Bull. Zool. Nomencl. 37(2): 114-116 (19 June) (... & George L. Kennedy) [see Opinion 1296, 2 April 1985]

1981

What is *Venericardia morsei* Dall? The Nautilus 95(4): 177-178 (29 Oct.)

1982

James Graham Cooper, Pioneer Western Naturalist. Moscow, Idaho (Univ. Press Idaho) 255 pp.; frontis.; map (22 Feb.)

Geographic uncertainties in the west American Donacidae. The Festivus 14(10): 124-127 (12 Oct.)

1983

The eastern Pacific Donacidae. The Veliger 25(4): 273-298; 7 pls. (1 April)

The life and contributions of James Graham Cooper. Amer. Malac. Bull. 2: 89 (July) [abst.]

Geographic uncertainties in the west American Donacidae. Western Soc. Malac., Ann. Rept. 15: 16 (30 Aug.) [abst.]

James Graham Cooper. Pioneer naturalist and forest conservationist. Journ. Forest History 27(3): 126-129 (15 Sept.)

A *Semele* story (Bivalvia: Semelidae). The Nautilus 97(4): 132-134 (28 Oct.)

1984

The Recent Crassatellinae of the eastern Pacific, with some notes on *Crassinella*. The Veliger 26(3): 153-169 (3 Jan.)

What is *Ervilia californica* Dall? The Nautilus 98(1): 11 (30 Jan.)

A taxonomic revision of the Crassatellinae of the eastern Pacific, with some comments on the biogeography of the Panama connection. Amer. Malac. Bull. 2: 83 (Feb.) [abst.]

[Review of] "Mollusca," by Kenneth J. Boss. The Veliger 26(4): 332 (2 April)

A taxonomic revision of the Crassatellinae of the eastern Pacific with some comments on the biogeography of the Panama connection. Western Soc. Malac., Ann. Rept. 16: 13 (31 May) [abst.]

S. Stillman Berry, 1887-1984. The Veliger 27(1): 99 (2 July)

The Bernardinidae of the eastern Pacific (Mollusca: Bivalvia). The Veliger 27(2): 227-237 (5 Oct.)

[Review of] "Distribution of Shallow-water Marine Marine Mollusca, Yucatan Peninsula, Mexico," by Harold E. Vokes & Emily H. Vokes. The Veliger 27(2): 244 (5 Oct.)

1985

The Bernardinidae of the eastern Pacific (Bivalvia). Amer. Malac. Bull. 3(1): 103 (Feb.) [abst.]

A bibliography and list of molluscan names of Josiah Keep. The Veliger 28(2): 211-215 (1 Oct.)

Concerning Carpenter's "first duplicate series" of Mazatlan shells. The Veliger 28(2): 216 (1 Oct.) (... & Joseph Rosewater)

Some additional notes on the distributions of eastern Pacific Donacidae. The Veliger 28(2): 217 (1 Oct.)

1986

The malacological contributions of Josiah Keep and Henry Hemphill. Western Soc. Malac., Ann. Rept. 18: 10-12 (31 Jan.) [abst.]

Some additional taxonomic units that first appear in publications by J. G. Cooper. The Nautilus 100(1): 30-32 (31 Jan.)

Myra Keen, 1905-1986: an appreciation. The Festivus 18(2): 14-15 (13 Feb.)

A. Myra Keen (1905-1986). The Veliger 29(1): 2 (1 July)

Rediscovery and identity of the holotype of *Helminthoglypta diabloensis* (Cooper) (Gastropoda: Pulmonata). Southern Calif. Acad. Sci., Bull. 85(2): 65-68 (? Oct.) [Barry Roth & ...] [fig. also reproduced on issue cover]

A. Myra Keen (1905-1986): list of molluscan taxa; malacological bibliography. Malacologia 27(2): 383-397 (17 Dec.)

1987

The malacological taxa of Henry Hemphill. The Veliger 29(3): 322-339 (2 Jan.) (... & Barry Roth)

A. Myra Keen, 1905-1986: a tribute. Western Soc. Malac., Ann. Rept. 19: 7-8 (9 March)

Concerning the type material of *Lasaea subviridis* Dall, 1899. The Veliger 29(4): 445 (1 April)

[Review of] "Isla de Gorgona," by Henry Von Prahl & Michael Alberico. The Veliger 30(1): 104 (1 July)

[Review of] "A faunal study of the bivalves of San Felipe and Environs, Gulf of California, from the Gemmell Collection (1965 to 1976)," by Joyce Gemmell, Barbara W. Myers & Carole M. Hertz. The Veliger 30(2): 212 (1 Oct.)

1988

The eastern Pacific species of *Semele*. Western Soc. Malac., Ann. Rept. 20: 26 (8 March) [abst.]

[Review of] "Marine invertebrates of the Pacific Northwest," by Eugene N. Kozloff. The Veliger 30(4): 427 (1 April)

Recent eastern Pacific species of the bivalve genus *Semele*. The Veliger 31(1/2): 1-42; 63 figs. (1 July)

The Recent invertebrate taxa described by William More Gabb, 1839-1878. Acad. Natur. Sci. Philadelphia, Proc. 140(1): 273-284 (28 July 1988) (... & Arthur E. Bogan)

The role of the amateur in the development of malacology in the western United States. The Festivus 20(10): 94-103; 20 figs. (13 Oct. 1988)

Common and scientific names of aquatic invertebrates from the United States and Canada: Mollusks. American Fisheries Soc., Spec. Publ. 16: vii + 277 pp.; 12 pls. (Donna D. Turgeon, Arthur E. Bogan, Eugene V. Coan, et al.) (17 Nov.)

1989

The publications and taxa of the Reverend Joseph Rowell (1820-1918). The Veliger 32(1): 43-46; 1 fig. (3 Jan.)

Some bivalve records from the Galapagos Islands. Western Soc. Malacologists, Ann. Rept. 21: 11-12 (7 March)

The malacological papers and taxa of Martha Burton Woodhead Williamson, 1843-1922, and the Isaac Lea Chapter of the Agassiz Association. The Veliger 32(3): 296-301; 2 figs. (3 July)

[Review of] "A classification of the living Mollusca," by Kay Cunningham Vaught. The Veliger 32(3): 331 (3 July)

1990

The Recent eastern Pacific species of the bivalve family Thraciidae. The Veliger 33(1): 20-55; 51 figs. (2 Jan.)

The malacological contributions of Ida Shepard Oldroyd and Tom Shaw Oldroyd. The Veliger 33(2): 174-184; 4 figs. (2 April) (... & Michael G. Kellogg)

The eastern Pacific species of the bivalve family Spheniopsidae. The Veliger 33(4): 394-401; 12 figs. (1 Oct.)

The molluscan publications of taxa of Lorenzo Gordin Yates (1837-1909). The Veliger 33(4): 402-407; 3 figs. (Oct.) (... & Paul Scott)

1991

Corbula kelseyi unmasked: a *Cumingia* (Bivalvia). The Veliger 34(4): 366 (1 Oct.) (... & Paul Scott)

1992

First International Latin American Malacological Congress, Caracas, Venezuela, 15-18 July 1991; proposed north-south collaboration. The Veliger 35(1): 91-91 (2 Jan.) (..., Melbourne R. Carriker, & Donald R. Moore)

[Reviews of] "The malacofauna of Hong Kong and southern China," ed. by Brian Morton; "Manglares y hombres del Pacifico Colombiano," by Henry von Prahl, Jaime R. Cantera & Rafael Contreras; and "Dvustvorchatye molliuski shl'fov kontinental'nogo sklona severnoi Patsifiki," by Alexander I. Kanfanov. The Veliger 35(3): 243 (1 July)

[in press]

Publication dates of *The Nautilus*. The Nautilus 106(3).

(... & M. G. Harasewych)

Minutes
Executive Board Meeting
Western Society of Malacologists
Asilomar, California
30 June 1992

President Mulliner called the meeting to order at 4:42 p.m.

Present: David Mulliner, Henry Chaney, Clif Coney, Kirstie Kaiser, George Metz, Paul Scott.

Secretary's Report: The 1991 minutes were approved as summarized.

Treasurer's Report: H. Chaney reported as follows:

As of the 1992 annual meeting, income for 1992 was $3345.00 which includes $2197 in dues received, and $319 donated to the symposium fund, and $346 for the student grant fund. $1000 was earmarked for the 1992 student grant. At the time of the annual meeting 38 members had not yet renewed, but most of these were expected to send in 1992 dues by the end of the summer.

Net worth as of the 1992 annual meeting was $11,250, with $1,900 in checking, $500 in savings, and $8,800 on deposit. $500 is earmarked for the next annual meeting at La Jolla, California.

Student Best Paper: Committee member David Mulliner reported that only one student paper was submitted for this meeting.

Treasurer Chaney recommended that one copy of the WSM Annual Report be awarded to this student in lieu of offering a 1992 Student Best Paper.

Student Grant: Chairman Paul Scott announced that 23 proposals were received for this year's student grant, totaling $31, 328 in requests. The Student Grant Committee will meet on 1 July to select the winners. Winners will be announced at the Annual Business Meeting.

Nominating Committee: Slate of officers for 1993 are as follows:

President	Douglas Eernisse
First Vice President	Kirstie Kaiser
Second Vice President	Nora Foster
Treasurer	Henry Chaney
Secretary	Clif Coney
Members at Large	Lindsey Groves Edna Naranjo-Garcia

The above slate was unanimously approved by the board.

Annual Report: The production of the 1991 WSM Annual Report cost $1,356. Two hundred seventy-five copies were printed with 210 copies mailed. Treasurer Chaney pointed out that the cost of the 1991 WSM Annual Report was significantly reduced by the use of in-house word processing. A motion to accept Hans Bertsch as Volume 25 Editor was made by President Mulliner and was unanimously approved.

Symposia Fund: The 1992 symposia were underwritten by a symposium fund of $484.00, used to support 2 participants.

New Business: Treasurer Henry Chaney proposed a reimbursement of $500 from the WSM treasury to the Santa Barbara Museum of Natural History to pay for software that was used for production of the WSM Annual Report.

Past president Paul Scott announced that the 1991 bivalve workshop held at Moss Landing was very successful with 10 malacologists in attendance. Proceedings of this workshop will appear in The Veliger.

David Mulliner reported that 9 of 10 award of honor ballots were returned. President Mulliner presented the committee with two elegant certificates of appreciation to Drs. Eugene V. Coan and Kikutaro Baba for their achievements in Malacology. Dr. Judy Terry Smith was selected to present the award at the WSM annual banquet. Dr. Smith would receive 25th year membership congratulations at the annual banquet.

The new historian for the WSM is Jody Woolsey.

There being no further business, the meeting was adjourned at 5:15 p.m. by President Mulliner.

Respectfully submitted by Clifton Coney, Secretary.

Minutes
Annual Business Meeting
Western Society of Malacologists
Asilomar, California
3 July 1992

President Mulliner called the meeting to order at 3:32 p.m.

Secretary's Report: The 1991 minutes were read by secretary Clif Coney.

Treasurer's Report: Treasurer Henry Chaney reported that as of the 1992 annual meeting, income for 1992 was $3345.00 which includes $2197 in dues received, and $319 donated to the symposium fund. The 1992 WSM Auction and reprint sales brought in a total of $1,200 with $88 resulting from reprint sales, giving a net profit of $1240. There are a total of 172 members, consisting of 125 regular members. There are 38 memberships with dues outstanding.

Student Best Paper: President Mulliner announced that Christine Henderson of California State University, Northridge would receive membership in the WSM and Volume 25 of the WSM Annual Report. This was awarded for her paper entitled "Effects of seasonality on the ecology and community structure of opisthobranchs from the central Gulf of California."

Student Grant: WSM Student Grant Committee Chairperson Paul Scott reported that there were 23 applicants, including 1 undergraduate, 7 Master of Science, and 15 Doctor of Philosophy candidates.

The WSM Student Grant award of $2,250 was split between the following top four student proposals.

Hsiu-Ping Liu, Ph.D. candidate at the University of Colorado, was awarded $750 for her proposal entitled, "A systematic study of the family Physidae in Colorado."

Ellinor Michel, Ph.D. candidate at the University of Arizona, was awarded $750 for her proposal entitled "Diversity in an African rift lake: Is it maintained by differences in feeding structures?"

Steven A. Osborn, Masters candidate at Moss Landing Marine Laboratories, was awarded $500 for his proposal entitled "Octopus oviducal gland structure: A morphologic trait with phylogenetic implications."

Mark Douglas Norman, Ph.D. candidate at the University of Melbourne, Australia, was awarded $250 for his proposal entitled "Contribution towards electron microscopy, photography and publication costs."

These awards were unanimously approved by the membership.

Nominating Committee: Nominating Chairperson Paul Scott announced the 1992 slate of officers as follows:

President	Douglas Eernisse
First Vice President	Kirstie Kaiser
Second Vice President	Nora Foster
Treasurer	Henry Chaney
Secretary	Clif Coney
Members at Large	Lindsey Groves Edna Naranjo-Garcia

The 1993 slate of officers was unanimously approved by the membership.

Annual Report: Editor Hans Bertsch reported that Paul Scott was doing a superb job of production of the Annual Report using computerized desktop publishing.

Western Society of Malacologists
1992

1993 WSM Meeting: President Mulliner requested a report from President-Elect Dr. Douglas Eernisse, who announced that the 1993 meeting would be held at La Jolla, California, and that three symposia were planned: (1) Current research on Polyplacophora; (2) Mollusks of the Sea of Cortez; (3) History of Malacology in the Western United States. Field trips are planned to the Hubbs Research Center, Scripps Aquarium, and George Kennedy will lead a field trip to local fossil beds

New Business: The 1992 symposia were underwritten by a symposium fund of $484.00, used to support two participants. President Mulliner proposed support for the 1993 symposia.

Paul Scott raised the issue of whether the WSM Student Grant should continue to be offered every year, or alternatively, once every two years. Terry Gosliner motioned that WSM Treasurer Henry Chaney advise on the financial ability of the WSM to endow a WSM Student Grant award each year. The Treasurer advised that sufficient funds would be available to endow the Student Grant award for 1993. The WSM membership approved that the endowment of future WSM Student Grant awards be activated based upon the advice of the Treasurer after an analysis of forthcoming WSM annual income.

Editor Hans Bertsch's proposed 25 year index to the WSM Annual Report was reported by Dr. Bertsch to be completed through volume 24.

President Mulliner graciously passed the WSM gavel to President-Elect Dr. Douglas Eernisse.

There being no further business, the meeting was adjourned at 4:20 p.m. by President-Elect Dr. Eernisse.

Respectfully submitted by Clifton Coney, Secretary

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1991 - 30 September 1992

INCOME

Membership dues	$2197.00	
Student grant donations (1992)	346.00	
Symposium fund	319.00	
Publication sales and page charges	50.00	
Interest on savings accounts	391.27	
Auction and reprint sales	1240.00	
Miscellaneous income	35.74	
1992 Conference	11,119.92	
TOTAL INCOME during period		$15,698.93

EXPENSES

Annual report	$1952.62	
Memberships and fees	47.00	
Reimbursements to officers	187.69	
1992 Student grant	1000.00	
1992 Symposium expenses	484.00	
1992 Conference	9966.43	
1993 Meeting advance deposit	500.00	
TOTAL EXPENSES during period		$14,137.74
Net gain for period		1,561.19
Beginning balance (1 October 1991)		10,119.71
NET WORTH on 1 October 1992		$11,680.90

Regular Individual Memberships

As a tribute to our Society's 25th Anniversary, WSM Charter Members are recognized by an asterisk

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THE WESTERN SOCIETY OF MALACOLOGISTS

ANNUAL REPORT
VOLUME 26

1993

The Western Society of Malacologists

Annual Report

Volume 26

Abstracts and Proceedings of the
Annual Meeting
Held at the Radisson Hotel
La Jolla, California
27 June - 1 July 1993

Issued:
26 June 1994

Editorial Board, Volume 26
Hans Bertsch, Editor-in-Chief
Paul H. Scott, Production Editor

The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the **Annual Report** is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $15.00 for regular members, $17.00 family, and $6.00 student.

The Western Society of Malacologists has issued three **Occasional Papers** – No. 1, "'Sea Shells of the Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan; and No. 3, "Twenty-five Year Index to Publications of the Western Society of Malacologists: Author, Taxonomic, Geographic and Subject Indices," by Hans Bertsch.

Correspondence regarding membership and orders for additional or back issues of the **Annual Report** or the **Occasional Papers** should be addressed to the current W.S.M. Treasurer, Dr. Henry Chaney, Museum of Natural History, 2559 Puesta del Sol Road, Santa Barbara, California 93105 USA.

In Memoriam

C. Clifton Coney, Los Angeles, California

Leroy H. Poorman, Westminster, California

Richard S. "Joe" Houbrick, Washington, D.C.

INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8 1/2" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers)** to the Editor: Dr. Hans Bertsch, Chair, Department of Mathematics & Natural Sciences, National University, 4125 Camino del Rio South, San Diego, CA 92018 USA.

ACKNOWLEDGMENTS: This report was produced utilizing the desktop publishing facilities at the Santa Barbara Museum of Natural History.

This publication is printed entirely on recycled paper.

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SYMPOSIUM ON CONTEMPORARY RESEARCH ON MOLLUSCA

Conveners:
Paul H. Scott
Santa Barbara Museum of Natural History
and
Douglas J. Eernisse
Museum of Zoology
University of Michigan

PHYLOGEOGRAPHY AND SPECIATION IN MOLLUSCS

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Allozyme variation, used in conjunction with traditional methods, permits the reconstruction of phylogeographic history of populations and species. Once related species have been identified it becomes possible to investigate the processes that led to their differentiation and speciation. I will review several cases in which I have used Nei's multilocus genetic distance, D, to characterize molluscan species and their modes of origination.

In the Bahamian pulmonate land snails of the genus *Cerion*, allopatric and parapatric speciation processes have produced less than 30 (not 300 as previously reported) conchologically distinct semispecies with unusually low interspecific genetic distances (D=0.05). These species have genetic cohesion despite the fact that they are still capable of hybridization. The genus also provides examples of so-called area effect speciation and hybridogenesis.

Clearer examples of allopatric speciation are provided by the *Nautilus* of Palau and New Caledonia which appear to have arisen by peripatric speciation from the centrally distributed *N. pompilius,* and by Chinese *Oncomelania hupensis* which appears to have colonized and speciated in the Philippines and subsequently in Sulawesi. Finally, allozymic variation suggests that the spectacular radiation of 26 species of camaenid land snails described by Alan Solem on the isolated 42 km long Ningbing Range of NW Australia resulted from repeated microgeographic allopatric speciation in three genera.

In contrast, two other cases involving six species of South American *Biomphalaria* and 21 species of Thai *Corbicula* illustrate the difficulty of making inferences about speciation without adequate genetic distance and phylogeographic data.

MORPHOGENETIC PROGRAMS AND EVOLUTION IN THE GASTROPODA

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For many years, malacologists have used developmental data to reconstruct the early evolution of the torsioned gastropod body form. Inferences have been drawn mainly from morphogenetic sequences observed for the non-feeding ontogenies of archaeogastropods. The traditional view explains ancestral torsion as a 180° rotation of shell, anus, and mantle cavities that resulted from an altered larval morphogenetic program. This evolutionary scenario, and its apparent recapitulation during archaeogastropod development, has satisfied the available neontological data to such an extent that it has almost entered the arena of unquestioned ideas, despite the fact that the scenario has generated major controversies about certain Paleozoic gastropod-like fossils. However, a closer scrutiny and comparison of morphogenetic sequences in gastropod groups, particularly comparisons that include opisthobranch ontogenies, reveal data that cannot be easily reconciled with the notion that extant, non-feeding archaeogastropod ontogenies epitomize the original pattern for all gastropods. I will argue that young, planktotrophic opisthobranch larvae may be the best extant approximation of the ancestral gastropod larval form, and that heterochrony has played a major role in shaping larval forms among the Gastropoda.

WHY SNAILS RADIATE: A REVIEW OF GASTROPOD EVOLUTION IN LONG-LIVED LAKES

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Long-lived lakes are theaters for evolution, where reoccurrence of species radiations in different parts of the world and in different geologic periods have been seen as replication of an evolutionary experiment. The lakes themselves seem to spur radiations because of physical features of the lake's age, depth, and habitat complexity and biological features of open niches or biotic complexity.

In gastropods, certain clades (the hydrobioid and ceritheacean prosobranchs and planorbid pulmonates) show repeated patterns of diversification in both extant and fossil long-lived lakes, revealing the common characters that make them prone to speciate. In general, prosobranchs are more sensitive to diversification stimuli, forming more endemic species which seem more highly derived than pulmonates.

Fossil gastropod radiations illuminate differences in pattern and rate of intralacustrine speciation that are not discernible in extant faunas. The process of diversification is tied to intrinsic characters shared by many of these clades: reproductive and dispersal strategies (brooders and poor dispersers), genetic structure (tightly constrained genetic systems), morphology (often relatively thick and ornamented shells), substrate specificity (hard bottom stenotopy) and physiology (depth tolerance). Trophic differentiability and behavior may also be influential, but have been poorly investigated. Hypotheses about the relative importance of these intrinsic characters can only be tested in a phylogenetic framework. The most notable examples of these evolutionary theaters are extant lakes Tanganyika, Baikal, Ohrid. Biwa, Titicaca, and fossil lakes Steinheim, Pannonian Parathys, Idaho, Biwa and Turkana.

PHYLOGENETIC AFFINITIES OF THE FAMILY OSTREIDAE BASED ON 18s rRNA

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Anatomical and paleontological data have contributed greatly to our understanding of evolutionary pathways in the Class Bivalvia. Despite these data, many key phylogenetic relationships remain unresolved, including the origin of oysters. The present research addresses this aspect of bivalve evolution by developing molecular phylogenies based on selected portions of the 18s rRNA gene.

Preliminary analyses suggest that certain conservative regions of the 18s rRNA gene will be useful for assessing higher level relationships in the Subclass Pteriomorphia. In the present study, a 800 base pair segment of the central region of the 18s rRNA gene was amplified using the polymerase chain reaction (PCR). Direct sequencing followed USB Sequenase version 2.0 protocol. Sequence comparisons of the 18s rRNA sequences for 10 bivalve taxa reveal a highly divergent segment (75 bp) within this otherwise conservative region. Maximum-parsimony analysis using PAUP 3.1 produce 6 minimum length trees of 300 steps and 54 trees of 301 steps. The trees having 301 steps are more congruent with present anatomical data and both sets of trees align the oyster (*Crassostrea virginica*) closer to the pearl oyster (*Isognomon alatus*) than to the scallop (*Placopecten magelanicus*). Sampling of more taxa will supplement this data set and help resolve competing phylogenetic and taxonomic schemes for the Pteriomorphia.

This research was made possible by the American Museum of Natural History Lerner Gray Grant.

MOLECULAR METHOD FOR SPECIES IDENTIFICATION IN THE FAMILY PHYSIDAE

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The current classification of Physidae is unsatisfactory due primarily to the paucity of diagnostic characters. Variation in the shell, anatomy, teeth, jaw structure, immunological properties and life history have not provided the diagnostic characters needed to infer phylogenetic relationships. Our recent survey of protein variation revealed numerous differences among species and provided the information necessary to estimate phylogenetic relationships. However we found no fixed allele differences between *Physa cupreonitens* and *Physa anatina*.

Several DNA techniques are being employed to search for additional genetic markers. Physid mitochondrial DNA is being probed to search for informative restriction fragment length polymorphisms (RFLP's). In addition, variable regions of the mitochondrial and nuclear genome have been amplified by the polymerase chain reaction (PCR) to search for RFLPs.

PREPARATION OF A GENOMIC LIBRARY FROM THE MARINE GASTROPOD *LITTORINA LITTOREA* (MOLLUSCA, PROSOBRANCHIA)

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A genomic library of the marine snail *Littorina littorea* was constructed from DNA isolated from gill and kidney tissues. The DNA was digested with SAU3AI, and 9-20 kilobase fragments were isolated using a sucrose density gradient. The fragments were partially filled-in with dGTP and dATP to prevent self-annealing, and the modified fragments were then ligated to the arms of the Lambda Fix vector. The recombinant bacteriophages were able to infect various strains of *Escherichia coli* that were designed to be capable of only accepting and propagating phages with inserts. From this library, it will be possible to isolate different genes and to determine to what degree they have been conserved among different phyla.

MOLLUSCS AS BIOMONITORS OF COASTAL POLLUTION? AN INSIDE LOOK AT THE ASSUMPTIONS

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A number of studies have advocated the use of marine molluscs as biomonitors to study fluctuations in the metal content of coastal waters. There are two basic assumptions with this procedure. First, that there is a quantitative relationship between the body load of metal in the tissues and the concentrations of bioavailable metal in the environment. Second, that the animals are unable to regulate metal accumulation by modifying process of uptake, turnover and excretion. The cellular basis for the bioaccumulation of metals has been studied in the marine prosobranch gastropod *Littorina littorea* to establish if these assumptions are valid.

Ultrastructural studies of the metal accumulating cells indicate that they can be divided into two types on the basis of function; namely metal storage and metal detoxifying cells. Moreover, subcellular chemical analyses of these cells demonstrate that the metals partition themselves into two separate ligand pools on the basis of chemistry and ligand binding preferences. Energy dispersive X-ray microanalyses show that hard Lewis acid metals, such as Ca, Mg, Mn, Zn, are sequestered into intracellular biomineralized concretions rich in pyrophosphate/orthophosphate. Conversely, soft Lewis acid metals such as Cd, Hg and Ag are associated with cytosolic proteins. These metal bindings proteins have been isolated and purified by sequential size exclusion, ion exchange and reverse phase high performance liquid chromatography. Amino acid analyses demonstrate that they are rich in cysteine and probably correspond to a metallothionein class 1 protein.

The implications of these findings on the validity of using molluscs as biomonitors of environmental quality is discussed.

A NEARLY CONTINUOUS HOLOCENE RECORD OF MOLLUSCS FROM CEDAR BREAKS NATIONAL MONUMENT, UTAH

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A high altitude site (3181 m elevation) located on the boundary between the Great Basin and the Colorado Plateau in Cedar Breaks National Monument, Utah, hosts a stratigraphic section spanning the last 10,000 years. The section provides a nearly continuous record of molluscan communities from this southern-most glaciated area in Utah. These molluscan assemblages provide a record of climate change from the cool latest-glacial era through a moist, warm early-Holocene regime to a mid-Holocene dry period.

OBSERVATIONS ON A PROTOBRANCH BIVALVE FROM THE SAN JUAN ISLANDS

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The nutshell clam, *Acila castrensis,* is a subtidal deposit feeder commonly found in soft sediment habitats throughout the San Juan Islands, Washington, USA. It moves horizontally in the sediment and reaches 2 cm in length. At a site with a water depth of 50 feet, population densities are about 500/m^2. Five hundred individuals were marked, measured, sexed and released. Six months later, growth and dispersal were assessed from recaptured individuals. To determine the effect of *A. castrensis* on community development, adults over 3 mm in length were sieved from meter square plots delineated by sediment barriers. Transmission electron microscopy was used to follow the development of gametes. Studies are continuing on community ecology, larval development, reproductive biology, and general natural history of *A. castrensis.*

COMPARATIVE REPRODUCTIVE ANATOMY OF FEMALE OCTOPUSES

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Serial histological sections of the female reproductive systems were conducted for members of the Octopodinae and the Graneledoninae. Results have revealed new, currently undescribed, internal structures of the female reproductive system of octopuses and demonstrate how reproductive maturity affects the size and orientation of the internal structures of the oviducal glands. Results also provide what may prove to be valuable diagnostic characters for sub-family recognition, and suggest a new phylogenetic relationship for the sub-families of the Incirrata.

Past studies have focused on the male reproductive anatomy for the production of diagnostic characters for the recognition of various taxonomic groups. Results of this research suggest that more information (i.e. diagnostic characters, life history strategies) may be obtained from analyses of the often overlooked female reproductive anatomy, especially if one looks at the internal anatomy of the female reproductive system in addition to the more commonly described and illustrated surface morphology. Illustrations and/or descriptions of a cross-sectional view of the oviducal glands, as well as illustrations and/or descriptions of the internal structure of the proximal and distal oviducts, should be given whenever species are being described. Methods to eliminate the need for histological procedures are also discussed.

Malacofauna of Western Mexico Symposium

Convener:
Hans Bertsch
National University

ZOOGEOGRAPHIC RELATIONSHIPS OF OPISTHOBRANCH MOLLUSCS FROM THE SOUTHERN PORTION OF THE PANAMIC FAUNAL PROVINCE

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An analysis of recent research on Opisthobranchia occurring along the Pacific coast of Panama was presented.

DOES THE BUBBLE SNAIL *HAMINOEA ANGELENSIS* FROM THE GULF OF CALIFORNIA DIFFER FROM THE COMMON *HAMINOEA VESICULA*?

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Baker & Hanna (1927) described the shell of a new species of bubble snail found throughout the Gulf. The soft parts were not described. Subsequent reports of the shell are sparse and none include a description of the soft parts. The common bubble snail *Haminoea vesicula* (Gould, 1855) has been reported from Ketchikan, Alaska to nearly the tip of the outer coast of Baja. It is suspected that these two species may be shell variants as they differ only in that *H. angelensis* has a smaller size (to 12 mm), a greyish-yellow color and a broader upper portion of the barrel. Animals collected in the Gulf, having shells fitting the description of *H. angelensis* were examined using SEM. Comparison with *H. vesicula* produced some surprising results.

NATURAL HISTORY OF WEST MEXICAN MARINE MOLLUSCS: HABITAT, FEEDING RELATIONSHIPS, AND REPRODUCTIVE BEHAVIOR

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Records and analyses of the ecology and biology of molluscs in west Mexican oceanic waters, from the Gulf of California, the Pacific shores of Baja California, and mainland Mexico (zoogeographic data based on the summaries of Bertsch, 1991 and 1993) were discussed. This photographic essay presented visual data on the cryptic, predatory, and reproductive adaptations and behavior of west Mexican marine molluscs. Illustrations included the egg mass of *Chromodoris baumanni* Bertsch, 1970, copulatory behavior of *Hypselodoris ghiselini* Bertsch, 1978, *Chromodoris norrisi* Farmer, 1963, feeding on two different sponge species, cryptic undescribed species of a yellow porostome that lives and feeds on yellow sponge, color variation in the egg masses of *Cypraea annettae* Dall, 1909, ectoparasitic *Thyca callista* Berry, 1959, on its seastar *Phataria unifascialis* (Gray, 1840), and other molluscan interrelationships.

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OPISTHOBRANCH MOLLUSCS FROM ISLAS GUADALUPE, REVILLAGIGEDO AND TRES MARIAS, MEXICO

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During May-July 1978, the Scripps Institution of Oceanography's R/V *Alpha Helix* undertook a cruise from San Diego, California, to Valparaiso, Chile. The goal of Leg One of that journey was to make extensive collections of benthic macroalgae at Islas Guadalupe, Revillagigedo and Tres Marías, México. During the course of these efforts, I observed a total of 24 species of opisthobranch molluscs, including five new to science, one of which is so far known only from Isla Clarion.

Particularly noteworthy were large numbers, up to 31/m^2, of the anaspidean *Stylocheilus longicauda* (Quoy & Gaimard, 1824) crawling on algal beds of *Dictyota* sp. Highlights of the cruise and slides of the animals were shown.

THE BROODING CHITON, *LEPIDOCHITONA THOMASI* (PILSBRY, 1898), DISCOVERED ON THE OCEANIC ISLETS, ROCAS ALIJOS, MEXICO

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Rocas Alijos (24°57.6'N 115°46.0'W) is a remote group of oceanic rocks located about 350 km due west of I. Magdalena, Baja California. They are very narrow and of relatively recent volcanic origin, rising thousands of meters from the sea floor to slightly above or near the surface. The 1990 Cordell Expedition was able for the first time ever to briefly sample the intertidal fauna of Rocas Alijos, and among these samples were collections of barnacle clusters.

During my 1992 visit to the California Academy of Sciences, Dusty Chivers showed me a small black chiton that he had discovered among these preserved barnacles. Upon my own examination of the barnacles, I discovered several additional adult specimens, and many tiny juveniles. These chitons were highly similar to specimens of *Lepidochitona thomasi* (Pilsbry, 1898) from central California, and I have provisionally identified them as such. *L. thomasi* is notable for its brooding habitat, an attribute consistent with the many juveniles observed among the Rocos Alijos material.

If further investigations confirm my preliminary identification, it would be a truly remarkable southern range extension of some 11° latitude. From my own previous studies, *L. thomasi* was reported to have a confirmed distribution restricted to the Monterey Peninsula and Big Sur coastline, a total range extending less than 1° latitude. Alternatively, this may be a previously undescribed species closely related to *L. thomasi* and the more northern brooder, *L. fernaldi* Eernisse, 1986.

KARYOLOGICAL ANALYSIS AND "G" BANDS OF *POMACEA FLAGELLATA* FROM SOUTHEAST MÉXICO

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Abstract

"G" bands in the karyotype of *Pomacea flagellata* were studied using routine techniques to obtain Trypsis-Giemsa (T-G) banding in mitotic chromosomes of embryonic cells. The results of this study may be useful in future research related to the cytogenetics and cytotaxonomy of these freshwater snails. There is an agreement in the diploid number and gross cytogenetic morphology among species in the genus *Pomacea*.

Introduction

Although freshwater snails have been widely studied in aspects of their biology, there have been few studies made in México on *Pomacea*. Most of these are based on morphological features such as the shell, the operculum, and the radula. Generally, the internal anatomical features of the *Pomacea* are not described.

Regarding the taxonomic position of these freshwater snails in México, they have had a mixed taxonomic history, based on anatomical analyses, descriptions of developmental or young shapes among the populations, and variation among different geographic localities.

The only genus of the family Ampullaridae now reported to occur in México is *Pomacea*. Bequaert (1957) and Pain (1964) mentioned only one species, *Pomacea flagellata* Say, 1827. Doubts on the identification of populations have been reported from several localities. In order to improve our understanding of the systematics of *Pomacea flagellata*, chromosomic features can be used as a taxonomic tool for the identification of populations of the genus *Pomacea*.

This species is considered one of the most economically important freshwater snails in México, because its wide distribution and abundance throughout southeast México facilitate its being cultivated as a food source.

This report describes the "G" banding chromosome patterns of *Pomacea flagellata* from the Grijalva River drainage system, in the state of Tabasco, México. The results of this study are compared with similar studies in allopatric populations of this species.

Materials and Methods

Mitotic chromosomes in metaphase (Figure 1) from embryonic cultures, using the technique proposed by Babrakzai and Miller, 1984, were measured, statistically analyzed, classified according to the analyses of Levan et al., 1964, and Al-Aish, 1969, and then were followed by "G" band characterization. The "G" bands were obtained by means of the simplified method reported by Wurster (1972).

Results

The distribution of "G" band patterns on the arms of chromosome pairs are consistent. Their location facilitates the correct identification, placement and analysis of chromosomically similar species.

The distribution pattern of "G" bands in *Pomacea flagellata* shows special characteristics for each chromosomal pair. These are illustrated in Figures 2 and 3, and numerically described in Table 1.

Discussion and Conclusion

Freshwater snails of the genus *Pomacea* are common in tropical regions, occurring in lagoons, rivers, lakes, dam reservoirs and other continental waters. These organisms are considered biologically and commercially interesting because their high economic potential can be developed through aquaculture techniques.

The main taxonomic problem among species of *Pomacea* has been the overnaming of species, resulting in numerous apparent synonymizations that are currently not resolved. Almost 30 different species have been described within this genus (Rangel, 1988). Contributing to the confusion are: shell variability (both shape and size) within a population, and soft body part descriptions (e.g., analysis of the head-foot complex, mantle cavity, osphradium, excretory and reproductive systems).

In his list of generic synonyms, Burch (1982) discussed possible synonymization among the genera *Ampullaria, Pila, Pomus, Conchylium,* and *Pomacea.* Regardless, Bequaert (1957) considered *Pomacea flagellata* the most common ampullarid from SE Veracruz, México, to Panamá and northern Colombia.

Although there is a great similarity in the karyological characteristics of the *Pomacea flagellata* chromosomes studied (Diupotex & Babrakzai, 1992, and Yam Keb, 1986), it is possible that the physiological and morphological heterogeneity observed among the populations may be a consequence of genetic heterogeneity. The study of "G" bands among mammals indicates there is some significance to different patterns of structural arrangements on chromosomes. Hence, this basic study technique may help resolve some of the taxonomic problems among *Pomacea flagellata.*

More studies should be conducted on banding patterns among the various populations of *Pomacea* species, to determine whether different variation patterns exist at the population level.

Acknowledgments

The author thanks Tec. José Andrés Reda Deara for help in collecting the samples of *Pomacea.*

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Chromosomic Pair Number	White Bands	Gray Bands	Black Bands	Total
1	1	5	3	9
2	4	3	2	9
3	3	1	3	7
4	1	3	3	7
5	3	2	6	11
6	2	2	2	6
7	3	3	2	8
8	3	3	3	9
9	2	3	2	7
10	3	3	1	7
11	3	2	3	8
12	2	2	3	7
13	2	2	2	6
Total	32	34	35	101

Table 1. "G" Bands in chromosomic pairs in the karyotype of *Pomacea flagellata*.

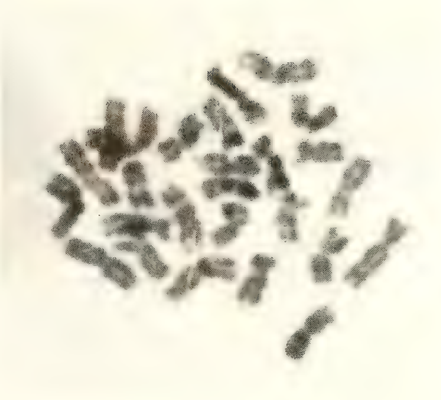

Figure 1. Mitotic chromosomes of *Pomacea flagellata*.

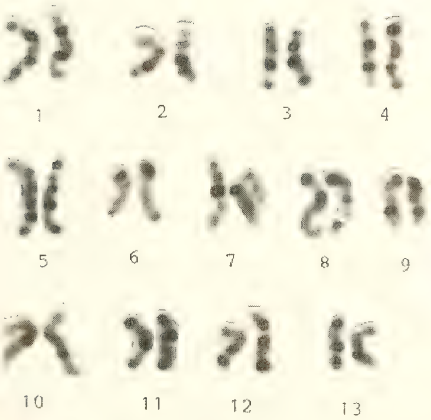

Figure 2. "G" band-pattern in the karyotype of *Pomacea flagellata*.

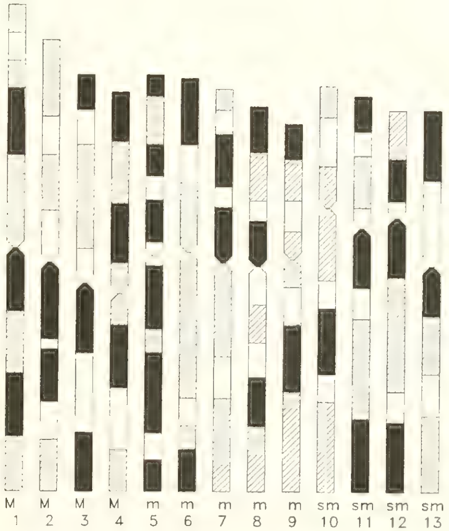

Figure 3. "G" band-pattern in the ideogram of the karyotype of *Pomacea flagellata*.

A PRELIMINARY SPECIES LIST OF THE SHELLED LAND SNAILS OF WESTERN MEXICO

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Although many landsnail collections have been made in western Mexico over the years, a comprehensive faunal list of this area is not available. When collecting at the tourist ports of Mazatlan, Puerto Vallarta, Zihuatenjo, and Acapulco, the need for such a list to aid in identification became apparent. Through literature searches I have prepared a species list of this area.

Covered are the states of Sonora, Sinaloa, Nayarit, Jalisco, Colima, Michoacan, Guerrero, and Oaxaca. Chiapas has been excluded because the continental divide comes almost to the Pacific, consequently Chiapas has a landsnail fauna more closely related to eastern Mexico. Baja California has also been excluded because of the excellent 1990 paper by Smith, Miller, Christensen, and Roth, "Land Mollusca of Baja California, Mexico" (in Proc. Calif. Acad. Sci., 47(4): 95-158). Western Mexico species also found in Baja California are indicated on the list. For each species references are cited and if figured this is noted. There is a reference list by state as well as a bibliography.

Though this is a preliminary list, it is hoped that it may benefit others interested in the landsnail fauna of this area of Mexico. If you are interested in a copy of the species list and bibliography, please contact me.

THE LAND SNAILS OF THE WESTERN COAST OF MEXICO

Edna Naranjo-Garcia
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The Mexican land snail fauna is largely unknown, possibly because of the size of the country, the total absence of local authorities in the field (until recently), and because the available information is scattered in numerous journals.

Identifying the material collected at the Chamela Biological Station to the specific level was difficult. It was mandatory to compile a list of species for, at least, the species known to inhabit the western Deciduous Forest of Mexico.

The western Deciduous Forest is distributed partly in Sonora, and in large areas in all of the other Pacific States. The compilation of the species list for the western Deciduous Forest now comprises all of the land mollusks recorded for the region.

The list is in a semi-raw state now. It consists of a compilation of any name given to a specimen, author, year of publication, locality and distribution data, and authors that have cited the species. Data from my explorations in Oaxaca, Michoacan and Jalisco have been added.

The first analysis of the information contained in the list, was a study of who had collected the specimens and when. I was personally interested in the historical atmosphere surrounding the specimens, especially if we consider the very few names of Mexicans attached to the terrestrial Malacology done in the country.

Brief History

Snails have attracted the attention of people for a long time. It seems that many of the species described, that possess collector's data, have been collected because of people's curiosity or casual encounter with shells and sometimes whole animals.

We are not sure yet when the first species of snail from the Pacific states of Mexico was described, but we do know that several famous collectors traversed the country in search of specimens. We have found that W. B. Gabb, A. Salle, A. Boucard, A. Morelet, and M. Rolle were among many others who explored the western coast between the 1800's to the 1890's.

From around 1890 to 1900, H.H. Smith, E. W. Nelson, S. N. Rhoads, Henry Edwards, J. G. Cooper and Dr. Mearns collected.

Several scientific explorations were conducted during the 19th century (like the Mission Scientifique au Mexique et dans l'Amerique Centrale).

From 1900 to 1919, T. Bland, A. Goldman, E. Lehnert and J. N. Rose were the prominent individuals who took back specimens to their countries.

In the period of 1920-1939, C.R. Orcutt, J. L. Bailey, H. A. Pilsbry and H. N. Lowe contributed molluscan material.

In the 1940's, several Mexicans (Ignacio Ancona, Pablo Roveglia and Alberto Arellano) sent material to the U. S. National Museum for identification.

In the fifties, Robert Drake explored the state of Sonora, J. A. Peters was in Jalisco and Michoacan, and W. Duellman in Colima.

In the sixties Fred G. Thompson, and three other companions, explored from Jalisco to Chiapas and reported several new species.

In the seventies A.H.S. Breure traveled in part of Mexico and published a new species of *Anisospira*.

Meanwhile, W. B. Miller visited the north-western side of Mexico and discovered several new species of *Sonorella* from Sonora.

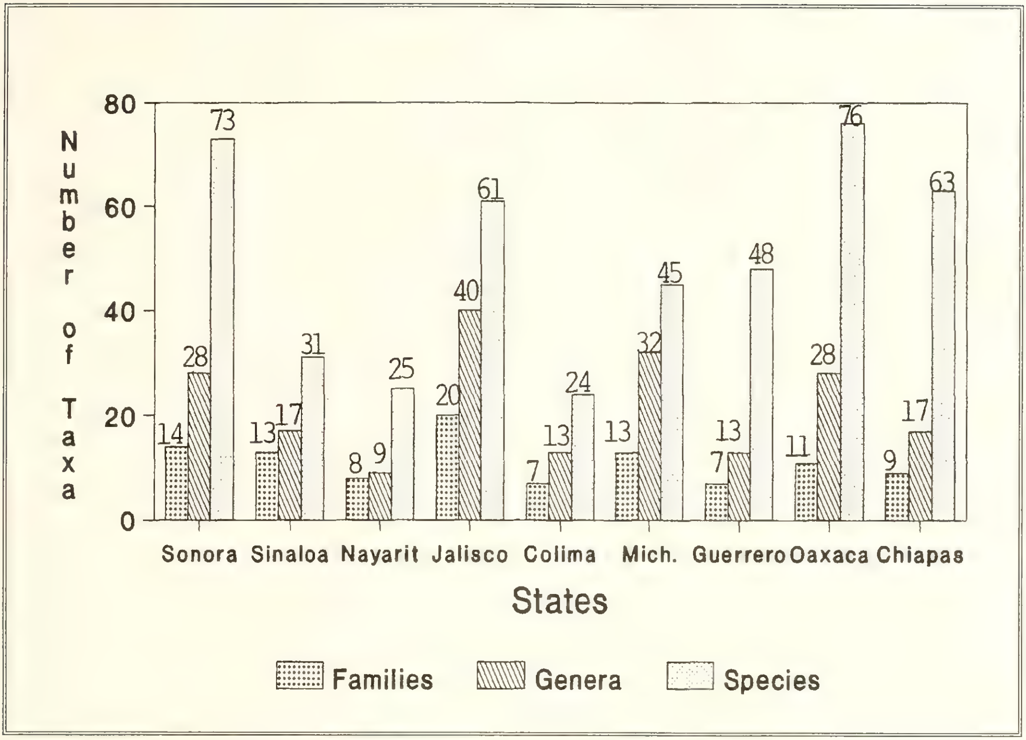

Figure 1. Taxa of land snails known from the Pacific States of México.

In the eighties W. B. Miller, J. Hoffman, J. Deisler and E. Naranjo-Garcia explored mainly the northern region of Sonora. At the same time O.J. Polaco and M. T. Olivera were doing studies in various sites of Mexico.

Of the many people who collected snails through almost two centuries, one can determine that professional malacologists did the most serious collecting during the last four decades.

At the present time the compiled list contains 445 species, 66 genera and 26 families.

Figure 1 shows the distribution of taxa per state, families, genera and species.

The states with more information are Oaxaca, Sonora, Chiapas and Jalisco.

Guerrero, Michoacan, Sinaloa, Nayarit and Colima are the least known states with 48, 45, 31, 25 and 24 species respectively.

The second analysis of the information contained in the species list was to calculate the Sorensen Index at the generic level.

The following tree (Figure 2) was obtained, showing three main branches, that can be interpreted as faunal differences. To the left, Sonora appears distinctly separate from the rest of the states. It shares some features with those states, however. In the southern region of Sonora, the more tropical fauna -coming from the south - penetrates - into the state (Naranjo-Garcia, 1991).

There is a main group composed by Jalisco, Michoacan, Sinaloa, Nayarit, Colima, Guerrero and Oaxaca.

Chiapas clearly segregates from the fauna of the central Pacific region.

The central Pacific region is then constituted by Jalisco, Michoacan, Sinaloa, Nayarit, Colima, Guerrero and Oaxaca, with a slightly more homogeneous fauna than that of Sonora or Chiapas.

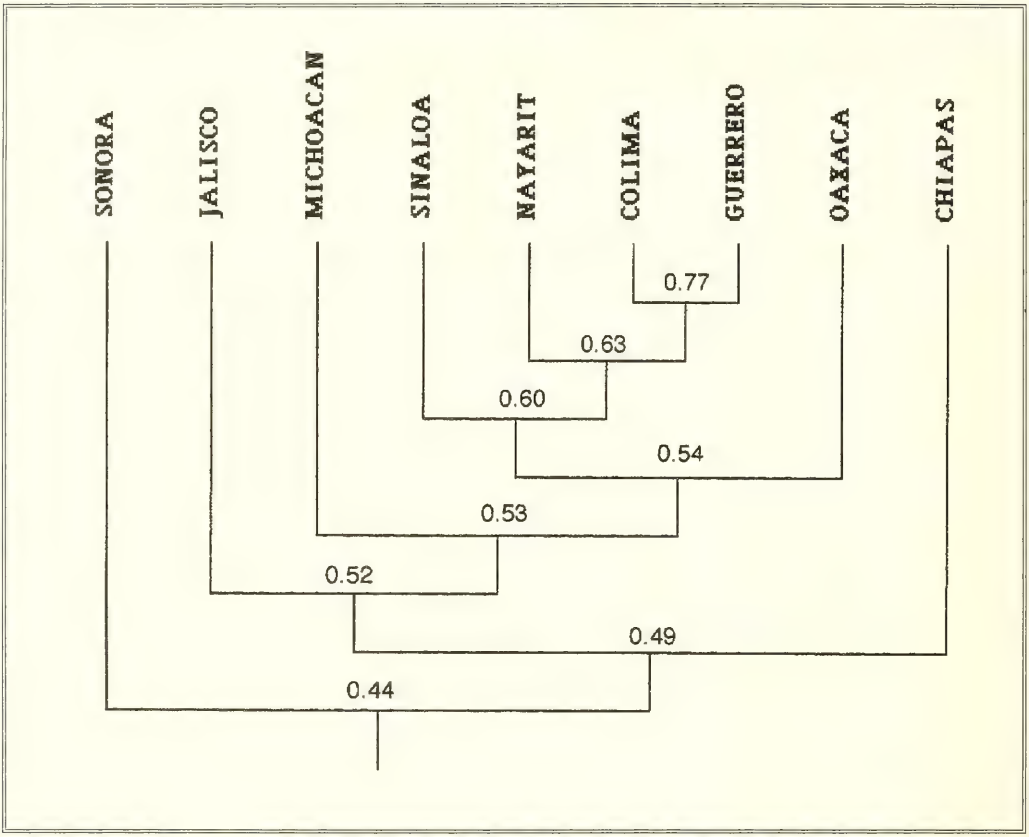

Figure 2. Generic-level tree calculated by the Sorensen Index showing land snail affinities in the Pacific States of México

The lack of geographical correlation among the states (central Pacific region) in the Sorensen Index chart is explained in part by the rather scarce information available for Sinaloa, Nayarit, Colima and Guerrero. A better definition on the relationships of fauna between states will be obtained when more information becomes available.

Jalisco

The species known from the literature for the state of Jalisco (44 to 61) was increased by 17 species, from the Chamela Biological Station and 18 other localities.

New taxa have been discovered from the material at hand, for example the genus *Polygyra* might have 6 new species distributed between the coast and Guadalajara, in the middle of Jalisco.

Twelve genera are first records for the state: cf. *Veronicella*, *Gastrocopta*, *Pupisoma*, *Vertigo*, *Lamellaxis*, *Leptinaria*, *Opeas*, *Spiraxis*, *Streptostyla*, cf. *Helicodiscus*, *Euconulus* and *Pallifera* .

Chamela Biological Station

At this site (where I am doing research on land snails) there are 20 families, 29 genera and 32 specific taxa, although only 7 (33%) of them have been identified to species. There are new species of the genera *Proserpinella* (manuscript submitted), *Thysanophora* and *Averellia*.

Conclusions

The list of species done so far, faces taxonomic problems, including:

- -Updating of names
- -Synonyms.
- -Erroneous identifications (species names from the Gulf of Mexico have been assigned to specimens of the western states. Those assignments are very unlikely (from my point of view), due to the distance involved, the type of vegetation, the weather and geographical barriers).
- -Genera such as *Orthalicus* and *Euglandina* need serious taxonomic studies.
- -The lack of professional malacologists in the country is reflected in the absence of micro snails reported in the literature for the Central Pacific region.

Literature Cited

Naranjo-Garcia, E. 1991. Present status of the micromollusks of northern Sonora, Mexico. American Malacological Bulletin 8(2): 165-171.

ROUND-TABLE DISCUSSION: RESEARCH IN WEST MEXICO

Moderator:

Hans Bertsch
National University

After a brief introduction, all symposium participants and attendees will be encouraged to formally describe and discuss their ideas regarding research agendas, difficulties encountered, interesting anecdotes, or any other pertinent comments regarding the study of molluscs in the west Mexico region. Special attention will be paid to international cooperation and joint research projects, as well as ways to publish new discoveries and to deposit type material in Mexican journals or institutions.

CONTRIBUTED PAPERS and POSTERS

REPRODUCTION IN *OCTOPUS RUBESCENS* BERRY, 1953 (MOLLUSCA: CEPHALOPODA)

Steven A. Osborn
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As part of a detailed study of the life history of *Octopus rubescens,* a chronological analysis of this species' reproductive processes (i.e. mating behavior, sperm storage, oogenesis, etc.) was conducted. Such information may provide additional insight into the complex reproductive process of octopuses, of which only a basic understanding currently exists. Thirty-one females and eighteen males were collected in Monterey Bay, CA over three consecutive breeding seasons (i.e. three years) and reared in the laboratory throughout their life cycle. Based on observed reproductive behaviors, laboratory experiments, and functional morphology ascertained through histological and electron microscopic techniques, information on the mating behavior, spermatophore transfer, spermatophore reaction, sperm deposition, sperm storage, oogenesis, egg fertilization, and egg laying has been obtained and is discussed.

PERIPHYTON-SNAIL INTERACTIONS IN STREAMS

Alan D. Steinman
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Snails are conspicuous and important benthic grazers in freshwater ecosystems. Studies conducted in the Pacific Northwest and eastern Tennessee, involving both field manipulations and laboratory streams, have revealed that the effects of grazing are density dependent. Usually, grazing results in reduced plant biomass, reduced area-specific primary production, increased biomass-specific primary production, reduced complexity in periphyton community structure, and reduced reliance on nutrient cycling to meet nutrient demand. However, at low densities, biomass may not be reduced and slight increases in area-specific primary production may occur. At high densities, a large potential exists for intraspecific and interspecific competition.

JAPANESE CONTRIBUTIONS TO OPISTHOBRANCH RESEARCH: PART II: THE WORKS OF SHINTARO HIRASE

Hans Bertsch
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Department of Mathematics and Natural Sciences
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Last year (Bertsch, 1993) I presented a paper on the contributions to opisthobranch research by my Japanese colleagues Takeo Abe, Iwao Hamatani, and Kikutaro Baba. This paper supplements that earlier presentation, with a brief biography of Shintaro Hirase and a list of his opisthobranch publications.

Shintaro Hirase was born on Awazi Island (at Hukura), on 28 February 1884. He died at the age of 55 at his home in Tokyo on September 29 1939, after a short kidney disease.

He was the eldest son of Yoichiro Hirase, also an outstanding conchologist.

Shintaro Hirase graduated from the Third College, and then took courses in psychology from the Faculty of Literature, at Kyoto Imperial University. In 1914 he matriculated at the Faculty of Science, Tokyo Imperial University. While taking graduate courses under the direction of Prof. Ijima, he studied *Stilifer celebensis*. He received his master's degree from the Tokyo Imperial University in 1917, and continued his post-graduate work from 1917 to 1922.

His research activities covered many areas of malacology. He completed a monograph on the oysters of Japan, and published "A Collection of Japanese Shells," including over 1360 species with numerous fine color plates.

He was a charter member of the Malacological Society of Japan, and was a member of several foreign malacological societies (of London, America, and Germany).

Shintaro Hirase dedicated himself to teaching the younger generation. He offered courses in natural science at the Meizi, Hosei and Sensyu Universities, and taught zoology courses at the Seikei College.

A portrait, obituary, and list of the malacological publications of Shintaro Hirase appeared in Venus 10 (1): 1-15 (1940).

Dr. Baba kindly provided me with the following list of Shintaro Hirase's publications on opisthobranchs.

Publications of Shintaro Hirase

1921. On *Dolabella*. Zool. Mag. 33: 478-479. (In Japanese)
1923. Studeis on the reproduction of *Dolabella* (Appendix). Classification of the Opisthobranchia based on the genitalia. Zool. Mag. 35: 395-400. (In Japanese)
1923. Anatomy of *Dolabella*. Zool. Mag. 35: 434-442. (In Japanese)
1927. Mollusca. In "Figuraro de Japanaj Bestoj": 1267-1503, plts. 15-16. Hokuryu-Kan, Tokyo. (In Japanese)
1929. Eiablage von *Dolabella*. Archiv für Molluskenkunde 61: 105-114.
1934. A collection of Japanese shells with illustrations in natural colors. xiv + 217 pp. Matsumura-Sanshodo, Tokyo
1936. On two new species of the Opisthobranchia from Japan. Zool. Mag. 48: 731-740. (In Japanese with an English abstract) (*Agjala iwasai* and *Berthella gotoi*)
1936. A new *Aglaja* from Japan. Jour. of Conch. 20: 258-261. (*Aglaja iwasai*)
1937. On a new *Berthella* from Japan. Proc. Malac. Soc. London 22: 177-181. (*Berthella gotoi*)

A MORPHOMETRIC ANALYSIS OF VARIATION IN RADULAR TEETH OF SYMPATRIC RADIATIVE ENDEMIC GASTROPODS FROM LAKE TANGANYIKA

Ellinor Michel
Department of Ecology and Evolutionary Biology
University of Arizona
Tucson, AZ 85721, USA

How do sympatric yet closely related clades maintain their ecological distinction? It has often been suggested that evolutionary plasticity in-feeding structures has allowed radiative endemics to become trophically subdivided and eventually, evolutionarily distinct. To test this idea, I examined the morphometric variation in radular teeth of members of the gastropod species flock in the genus *Lavigeria* from Lake Tanganyika. This is a model clade for exploring intralacustrine speciation because we find sympatric distributions-of many closely related species that are distinguished by differences in shell morphology, enzyme electromorphs, soft-part anatomy, and life history. This evidence indicates that there are approximately twelve species in this clade, not the currently described two. I took scanning electron micrographs of radulae from 6 Lavigeria species, all of which scrape algae from rocks.

Canonical discriminant analyses of 11 measured variables and 7 ratios from the micrographs revealed statistically significant differences between species which were independent of size, although these differences are not of greater magnitude than other indicators of species differences. Furthermore, there are allometric trends in growth of denticles on the radular teeth which may be useful phylogenetic indicators. Because differences in feeding structures in this clade are relatively subtle, I predict that trophic differences have not-been a driving force for divergence, as has been hypothesized for cichlid fish,-rather, they have been carried along as selection operates on other characters. I will evaluate this hypothesis in future work by examining stomach contents.

NEW ILLUSTRATIONS OF *CYPRAEA* RADULAE

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University of California
La Jolla, CA 92037, USA

Scanning electron microscope and optical microscope photographs have been made of the radulae of more than 190 species of *Cypraea*. Of these, 67 species have not previously been illustrated in the scientific literature.

As anticipated, radulae of *C. exusta* and *C. talpa* are found to be very similar. *C. bouteti* is found to be very similar to *C. carneola* and *C. propinqua*. Differences among the *C. teres* complex are small. The paper will include discussions of *C. histrio* and *C. grayana* compared with other members of the Mauritia group; *C. broderipii, C. bouteti* and *C. leucodon* vs. the Lycina group; *C. sakuraii* vs. *C. achatidea* and *C. teramachii;* and other comparisons.

GROWTH STAGES OF THE LANDSNAIL *CERION UVA UVA* (LINNAEUS, 1758) FROM CURACAO, NETHERLANDS ANTILLES

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Daly City, CA 94015

Much study has been devoted to adult *Cerion* but the young have been neglected. Through what growth stages is the shell shape of *Cerion uva uva* transformed as it matures? The shell begins depressed and at maturity is pupa-shaped. Using plotted data three stages can be deciphered. These are stage 1 - to height equals width; stage 2 - from height equals width to adulthood; and stage 3 - adulthood.

Stage 1 - "Youth" - The thin, translucent protoconch is depressed, the shell height being about half the diameter. The aperture is a narrow horizontal slit at the end of the body whorl. The number of whorls increases from 3 to 8 when the shell height equals the width at about 9 to 10 mm. The shell is perforate and tightly coiled (1.1 whorls per mm).

Stage 2 - "Immature" - Now the height begins to increase at a greater rate than the width. The shell becomes taller but not much wider. The narrow slit begins to increase in height becoming a horizontal rectangle. The former perforate shell is not imperforate. The whorls increase from 9 to 11, still tightly coiled (1.2 whorls per mm). The shell resembles the adult but with the adult body whorl removed.

Stage 3 - "Adult" - The shell again increases in height while the width remains the same. From a shell height of 17 mm the aperture changes from almost rectangular to oblong and reflected. A columellar fold develops in the aperture. The shell is again perforate. The whorls increase slowly as the height increases. Most adults have 11 to 13 whorls with an average of 1.3 whorls per mm.

PLATYDORIS MACFARLANDI HANNA, 1951, FROM BAHÍA DE SEBASTIÁN VIZCAÍNO AND ISLA NATIVIDAD, BAJA CALIFORNIA, MÉXICO

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San Diego, CA 92123

In his original description, Hanna worked with three specimens of *Platydoris macfarlandi* from Pismo Beach, California. A photograph of this species (Behrens, 1985) shows a tan animal with a thin white mantle rim and tan dorsum.

Behrens and Henderson (1983) redescribed the species from two specimens from Redondo Beach, California. The specimens they described were collected at depths between 200 and 300 feet

During a three week cruise in 1952 aboard the Scripps R/V *Paolina-T*, otter trawls were taken in Bahía de Sebastián Vizcaíno and Isla Natividad, Baja California, México. Eight specimens of *P. macfarlandi* were collected in these trawls at approximate depths of 288 feet. The specimens were documented with photographs that show the characteristic color patterns.

Behrens, David W. 1985. What color is *Platydoris*? A matter of light and depth. Shells and Sea Life 17(5):179-180, 1 pl.

Behrens, David W., and R. Henderson. 1983. Redescription of *Platydoris macfarlandi* Hanna, 1951 a rare deepwater doridacean nudibranch. Veliger 25(4):365-369.

Progress Reports from 1992 Student Grant Recipients

PROJECT TITLE: DIVERSITY IN AN AFRICAN RIFT LAKE: IS IT MAINTAINED BY DIFFERENCES IN FEEDING STRUCTURES?

Ellinor Michel
Department of Ecology & Evolutionary Biology
University of Arizona, Tucson, AZ

How do sympatric yet closely related clades maintain their ecological distinction? It has often been suggested that evolutionary plasticity in feeding structures has allowed radiative endemics to become trophically subdivided and eventually, evolutionarily distinct. To test this idea, I examined the radulae of members of the gastropod species flock in the genus *Lavigena* from Lake Tanganyika. The WSM provided financial assistance of $750 towards the costs of scanning electron microscopy. I took micrographs of radulae from 6 *Lavigena* species (120 individuals), all of which scrape algae from rocks. Canonical discriminant analyses of 11 measured variables and 7 ratios from the micrographs revealed statistically significant differences between species which were independent of size, although these differences are not of greater magnitude than other indicators of species differences. Furthermore, there are allometric trends in growth of denticles on the radular teeth which may be useful phylogenetic indicators. Because differences in feeding structures in this clade are relatively subtle, I predict that trophic differences have not been a driving force for divergence, as has been hypothesized for cichlid fish, rather, they have been carried along as selection operates on other characters. I will evaluate this hypothesis in future research by examining stomach contents.

This research has been the subject of two talks at professional conferences and was included as part of my talk at the WSM meeting in 1993 (references below). As a result of my work on *Lavigena* radulae, a Russian malacologist suggested I visit Lake Baikal to do a parallel study and compare divergence in radulae of the endemic gastropod fauna there. I am preparing a manuscript on radula morphometrics which will include SEM micrographs made possible by WSM support. New species descriptions will also include these micrographs. The WSM is acknowledged for its assistance and I will provide reprints when this work is published. By using SEM, I was able to uncover variation between species that was unknown to earlier workers.

Michel, E. 1993. Evolutionary Divergence in Gastropods from Long-lived Lakes: A comparison of Our Understanding from Morphological and Molecular Data. Symposium on Contemporary Research on Mollusca, Western Society of Malacologists Annual Meeting, La Jolla, CA, June 1993

Michel, E. 1993. Diversity in Feeding Structures and Species Flocks: The Snail's Eye View from Lake Tanganyika. Workshop on Speciation in Ancient Lakes (International Association of Theoretical & Applied Limnology and the Royal Belgian Institute of Natural Sciences), Brussels, Belgium, March 1993

Michel, E. 1992. Do Differences in Feeding Structures Maintain the Extraordinary Diversity in Lake Tanganyika? A Study of Radulae in the *Lavigena* Gastropod Species Flock. Evolution Meetings: Society for the Study of Evolution, Society of Systematic Biologists, American Society of Naturalists, Berkeley, CA, June 1992

I thank the Western Society of Malacologists, the Southwest Shell Club, the Santa Barbara Shell Club and the San Diego Shell Club for their support of my research on the *Lavigena* species radiation. Without your support I would not have been able to investigate the possibility of trophic divergence within this clade.

PROJECT TITLE: A SYSTEMATIC STUDY OF THE FAMILY PHYSIDAE

Hsiu-Ping Liu
Department of Environmental, Population, and Organismic Biology
Campus Box 334
University of Colorado
Boulder, CO 80309

My recent survey of protein variation revealed numerous differences among species and provided the information necessary for species identification and estimating phylogenetic relationships. However I found no fixed allele differences between *Physa cupreonitens* and *Physa anatina.* Therefore several DNA techniques are being employed to search for additional genetic markers.

Currently not all available methods of DNA extraction work well for the physid snails which produce large amount of mucus. Establishing the DNA extraction techniques that work well with physid snails will allow me to search for additional DNA markers (DNA markers can be used in situations where protein-electrophoresis methods have failed to reveal diagnostic differences).

At this stage, I have established total DNA and mitochondrial DNA extraction procedures and the techniques of mitochondrial DNA restriction fragment length polymorphisms (RFLPs). I have also successfully amplified regions of the mitochondrial and nuclear genome by the polymerase chain reaction (PCR) to search for RFLPs.

I have learned many techniques, and I am optimistic that I will be able to finish this project very soon. I will send a copy of final report as soon as I finish my experiments.

The financial support of WSM allowed me to established these experiment procedures and made this research possible. Sincere thanks for the financial and moral support offered by WSM through the Student Research Grant.

PROJECT TITLE: *OCTOPUS* OVIDUCAL GLAND STRUCTURE: A MORPHOLOGIC TRAIT WITH PHYLOGENETIC IMPLICATIONS

Steven A. Osborn
Moss Landing Marine Laboratories
P.O. Box 450
Moss Landing, CA 95039

In May of 1992, the Western Society of Malacologists provided financial support in the amount of $500.00 towards the costs of my research on the comparative reproductive anatomy of female octopuses. This funding has helped defer the costs of laboratory supplies, equipment, and space needed to conduct serial histological sectioning at the University of California at Santa Cruz. To date this research has revealed new, currently undescribed internal structures of the female reproductive system of octopuses as well as shedding light on how reproductive maturity effects the size and orientation of the internal structures of the oviducal glands. This research has also provided what may prove to be valuable diagnostic characters for subfamily recognition, and has suggested that a phylogenetic relationship may exist for the major groups of the Incirrata quite different than that proposed in current literature.

A preliminary study suggested possible species-level diagnostic characters may exist based on the internal oviducal gland anatomy of octopuses. Upon conducting the proposed research, major differences in the internal anatomy of the female reproductive system were unexpectedly found, encountering undescribed structures with unknown functions. It is unknown if these structures represent diagnostic characters at the species level since it is unknown if these structures can be found in higher taxonomic groups. To evaluate the diversity of the internal female reproductive anatomy within the Incirrata, the internal anatomy of the female reproductive system of one of the four major groups within the benthic octopods, the Graneledoninae, needed to be analyzed, as its reproductive anatomy has never been investigated. Results of the serial histological sections revealed convoluted areas within the proximal oviduct and an oviducal gland anatomy very similar to that found in the Octopodinae. Results from the histological observations of the Octopodinae and the Graneledoninae, along with information obtained from the literature on the reproductive anatomy of the Eledoninae and the Bathypolypodinae, may have provided simple diagnostic characters for subfamily recognition.

Current results also suggest a very different phylogenetic relationship for the Incirrata than that proposed by Voss in 1988. Current literature suggests the Graneledoninae are direct descendants of the Eledoninae. The Eledoninae have a very unique reproductive strategy and anatomy where sperm is stored directly within the ovary. No sperm storage structures exist within their oviducal glands. Results from the current study have revealed that the reproductive anatomy of the Octopodinae and the Graneledoninae are nearly identical consisting of the same internal structures (including the sperm storage areas within the oviducal glands) arranged identically. Based on the many dissimilarities of the reproductive anatomy between the Eledoninae and the Graneledoninae, and the surprisingly very similar reproductive anatomies of the Graneledoninae and the Octopodinae, a different phylogenetic relationship between these sub-families may be proposed with the Graneledoninae being more closely related to the Octopodinae than to the Eledoninae.

Past studies have focused on the male reproductive anatomy for the production of diagnostic characters to use for the recognition of various taxonomic groups. Results of the research conducted to-date suggest that more information (i.e. diagnostic characters, life history strategies, etc.) may be obtained from analyses of the often overlooked female reproductive anatomy. Also, an even greater amount of information may be obtained if one looks at the internal anatomy of the female reproductive system in addition to the more commonly described and illustrated surface morphology. Illustrations and/or descriptions of a cross-sectional view of the oviducal glands, as well as illustrations and/or descriptions of the internal structure of the proximal and distal oviduct, should be given whenever species are being described. Methods are currently being evaluated to eliminate the need for histological procedures in order to determine the internal anatomy of the female reproductive system in octopuses. Much more work is needed on this topic of internal female reproductive anatomy and research will continue as more specimens become available.

Sincere thanks to the Western Society of Malacologists not only for the financial and moral support offered to me, but for the support given by the WSM to the entire field of malacology. It is unfortunate that research endeavors, in essence one's own imagination and curiosity, are limited by financial constraints. The financial support offered by the WSM not only provides for a better understanding of the world around us, but helps nourish these traits, so essential to the field of science. The support you give is rare and I congratulate you.

PROJECT TITLE: SYSTEMATICS AND BIOGEOGRAPHY OF SHALLOW-WATER OCTOPUSES (CEPHALOPODA: OCTOPODINAE) OF THE GREAT BARRIER REEF, AUSTRALIA. (CONTRIBUTION TOWARDS ELECTRON MICROSCOPY COSTS.)

Mark D. Norman
Department of Zoology
University of Melbourne
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In 1992, the Western Society of Malacologists provided financial support of $250.00 towards the costs of my Ph.D. research. This funding was used to cover costs associated with Scanning Electron Microscopy (SEM), providing over 15 hours of use of the SEM in the Department of Zoology at the University of Melbourne. This time produced excellent images of the radula structure of the 16 species of shallow-water octopuses treated in my dissertation.

Examination of radula structure through SEM has enabled recognition of a number of new diagnostic characters and a new interpretation of the nature of octopus radulae. Radula teeth morphology and seriation have provided clues to supra-specific affinities amongst Great Barrier Reef species and may prove to be a valuable generic-level character.

At this stage, I have recognized more than 30 new species of shallow-water octopuses from northern Australia and I'm currently in the process of describing these species. I have four publications in press at the moment describing a number of these new species. These papers include SEM micrographs of radula structure for each species. These photographs provide much clearer recognition of radula features compared with the drawings made from light microscope slides used in many earlier works. The financial support of WSM made use of these images possible and this support is acknowledged in the following publications. Reprints of these publications will be forwarded as they become available.

Norman, M.D. 1993. Ocellate octopuses (Cephalopoda: Octopodidae) of the Great Barrier Reef, Australia: description of two new species and redescription of *Octopus polyzenia* Gray, 1849. *Memoirs of Museum of Victoria* (in press).

Norman, M.D. 1993. Four new species of the *Octopus macropus* group (Cephalopoda: Octopodidae) from the Great Barrier Reef Australia. *Memoirs of the Museum of Victoria* (in press).

Stranks, T. and M.D. Norman. 1993. Review of the *Octopus australis* complex (Cephalopoda: Octopodidae) and description of a new species. *Memoirs of the Museum of Victoria* (in press).

Norman, M.D. (in press). *Octopus ornatus* Gould, 1852 (Cephalopoda: Octopodidae) in Australian waters: morphology, distribution and life history. *Proceedings of the Biological Society of Washington*(in press).

I submitted my final Ph.D. dissertation in October 1992 in which the support of WSM was also acknowledged. I was informed early 1993 that my Ph.D. had been approved.

Sincere thanks for the financial and moral support offered by WSM through the Student Research Grant in Malacology.

Minutes
Executive Board Meeting
Western Society of Malacologists
La Jolla, California
27 June 1993

President Eernisse called the meeting to order at 1:37 p.m.

Present: Doug Eernisse, David Mulliner, Nora Foster, Kirstie Kaiser, Henry Chaney, George Kennedy, Edna Naranjo-Garcia, Paul Scott.

Secretary's Report: Due to the death of C. Coney, G. Kennedy was appointed Acting Secretary. In the absence of Coney's notes, a motion was passed to accept the minutes as published in the 1992 *Annual Report.*

Treasurer's Report: H. Chaney reported as follows:

As of the 1993 annual meeting, income for 1993 was approximately $2,600 which includes $1,800 in dues received, $262 donated to the symposium fund, $325 for the student grant fund, and $270 earned in interest. $1000 was earmarked for the 1993 student grant. At the time of the annual meeting 38 members had not yet renewed, but most of these were expected to send in 1993 dues by the end of the summer.

Net worth as of the 1993 annual meeting was about $11,000, with $1,900 in checking, $500 in savings, and $8,800 on deposit. $200 is earmarked for the next annual meeting at Santa Barbara, California.

Student Grant: Chairman Paul Scott announced that 13 proposals were received for this year's student grant. The Student Grant Committee (P. Scott, H. Chaney, G. Kennedy, E. Coan, W. Miller) will meet on 29 June to select the winners. Winners will be announced at the Annual Business Meeting.

Nominating Committee: Slate of officers for 1994 are as follows:

President	Kirstie L. Kaiser
First Vice President	Nora Foster
Second Vice President	Hugh Bradner
Treasurer	Henry Chaney
Secretary	Terry Arnold
Members at Large	Ken Lindahl Katherine Stewart

The above slate was unanimously approved by the board.

Annual Report: The production of the 1992 WSM Annual Report cost $1,270. Two hundred seventy-five copies were printed with 210 copies mailed. Treasurer Chaney pointed out that the cost of the 1992 WSM Annual Report was significantly reduced by the use of in-house word processing at the Santa Barbara Museum of Natural History. A motion to accept Hans Bertsch as Volume 26 Editor was made by President Eernisse and was unanimously approved.

Symposia Fund: The 1993 symposia were underwritten by a symposium fund of $563.00, used to support 5 participants.

New Business: President-elect K. Kaiser reported that the 1994 Annual meeting of the WSM will be held at the Miramar Hotel, on the beach in Montecito, California from Sunday, 26 June to Thursday, 30 June. The Santa Barbara Museum will host the beginning reception, an open house, and serve as the site for the annual banquet. Two symposia are planned, one on micromollusks organized by J. McLean, and one on molluscan zoogeography in honor of William K. Emerson. A motion was made to accept the meeting plan as outlined by K. Kaiser and was unanimously approved.

Second Vice-President Nora Foster reported that the 1995 Annual Meeting will be held in Fairbanks, Alaska during the week of 18 June. Possible symposia topics include benthic cephalopods, molluscan ecology, and Beringian mollusks past and present. A possible conflict with the 1995 AMU meeting in Hawaii was discussed and N. Foster will look into possible timing conflicts. A motion was made to accept the meeting plan as outlined by N. Foster, and was passed.

Discussion was made about standardizing duties of WSM officer, particularly those of Secretary and Treasurer. Treasurer H. Chaney will work with Secretary T. Arnold to resolve issues.

There being no further business, the meeting was adjourned at 2:42 p.m. by President Eernisse.

Respectfully submitted by George L. Kennedy, Acting Secretary.

Minutes
Annual Business Meeting
Western Society of Malacologists
La Jolla, California
30 June 1993

President Eernisse called the meeting to order at 3:51 p.m.

Secretary's Report: Acting Secretary George Kennedy read the minutes of the 1992 Business Meeting. A motion was made to accept the minutes as published in the 1992 Annual Report, and was passed.

Treasurer's Report: Treasurer Henry Chaney reported that as of the 1993 annual meeting, income for 1993 was approximately $2,600 which includes $1,800 in dues received, $262 donated to the symposium fund, $325 for the student grant fund, and $270 earned in interest. $1000 was earmarked for the 1993 student grant. At the time of the annual meeting 38 members had not yet renewed, but most of these were expected to send in 1993 dues by the end of the summer.

Net worth as of the 1993 annual meeting was about $11,000, with $1,900 in checking, $500 in savings, and $8,800 on deposit. $200 is earmarked for the next annual meeting at Santa Barbara, California.

Audit Committee: Jules Hertz reported that with only minor changes the committee found the Society's financial records to be in good order.

Student Best Paper: Nora Foster reported that four student papers were in contention for the Best Student Paper Award, which was presented to Ellinor Michel for her paper on "Why snails radiate: A review of gastropod evolution in long-lived lakes."

Student Grant: WSM Student Grant Committee Chairperson Paul Scott discussed the efforts of the past year, which included a follow-up on 1992 award winners (see pages 13-16 of this report). The WSM, San Diego Shell Club (SDSC), Santa Barbara Malacological Society (SBMS) and the Southwest Shell Club all received letters of thanks from the student winners.

For 1993 the WSM collaborated with the SDSC, the SBMS and the Northern California Malacozoological Club to fund grants. Of the 13 applicants there were 2 undergraduates, 3 Master of Science, and 8 Doctor of Philosophy candidates.

The WSM Student Grant was awarded among the following top three student proposals.

Kenneth Thomas, Ph.D. candidate at the University of Rhode Island was awarded $500 for his proposal "Survival on a New England mud flat: Reproduction, recruitment, growth and distribution of *Lyonsia hyalina* Conrad, 1831."

Deborah Gochfield and Greta Aeby, Ph.D. candidates at the University of Hawaii were awarded $225 for their joint proposal entitled "The role of predation as a potential factor limiting populations of the coral-eating nudibranch, *Phestilla sibogae*."

John Zardus, Ph.D. candidate at Northeastern University was awarded $200 for his project "Investigations on *Acila castrensis*."

These awards were unanimously approved by the membership.

Nominating Committee: Nominating Chairperson David Mulliner announced the 1993 slate of officers as follows:

President	Kirstie L. Kaiser
First Vice President	Nora Foster
Second Vice President	Hugh Bradner
Treasurer	Henry Chaney
Secretary	Terry Arnold
Members at Large	Ken Lindahl Katherine Stewart

The 1993 slate of officers was unanimously approved by the membership.

Annual Report: Hans Bertsch was once again appointed editor for Volume 26 of the Annual Report. Editor Bertsch requested that lengthier abstracts and short papers be submitted by members of the WSM. He reported that Production Editor, Paul Scott, produced the Annual Report and 25 Year Index using computerized desktop publishing facilities at the Santa Barbara Museum. Dr. Bertsch was given a round of applause for his work collating the 25 Year Index of the WSM Annual Report.

1994 WSM Meeting: President-elect K. Kaiser reported that the 1994 Annual meeting of the WSM will be held at the Miramar Hotel, on the beach in Montecito, California from Sunday, 26 June to Thursday, 30 June. The Santa Barbara Museum will host the beginning reception, an open house, and serve as the site for the annual banquet. Two symposia are planned, one on micromollusks organized by J. McLean, and one on molluscan zoogeography in honor of William K. Emerson. A motion was made to accept the meeting plan as outlined by K. Kaiser and was unanimously approved.

1995 Annual Meeting: Second Vice-President Nora Foster reported that the 1995 Annual Meeting will be held in Fairbanks, Alaska during the week of 18 June. Possible symposia topics include benthic cephalopods, molluscan ecology, and Beringian mollusks past and present. A possible fieldtrip to Valdez was suggested. Foster was asked by the membership to compile a summary sheet detailing costs for meeting participants.

The possibility of a joint meeting with the Conchologists of America was discussed, as the COA meeting will be in San Diego in 1995.

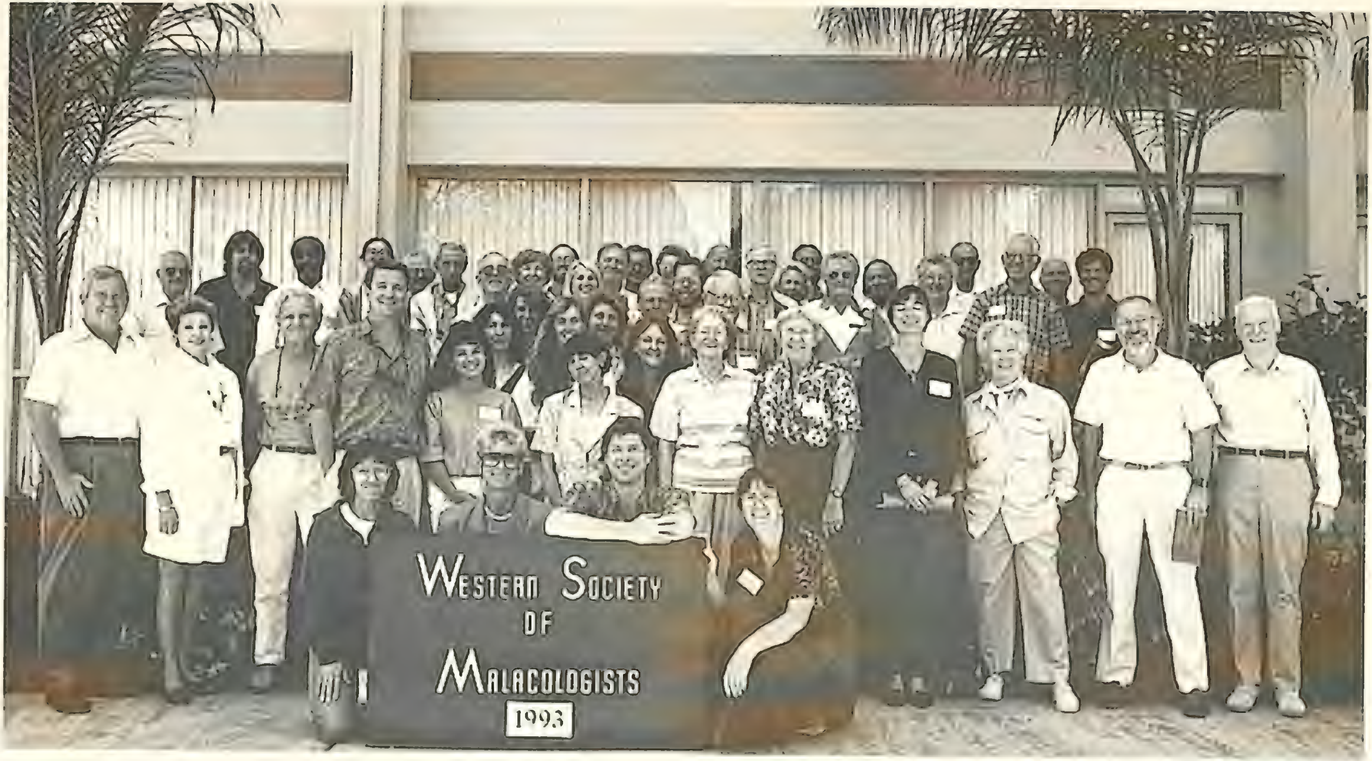
New Business: It was moved and seconded to fund the WSM student grant for $1,000 for the 1994 competition. The motion passed.

In Memoriam: It was moved, seconded and passed that the Society recognize the efforts of past Secretary C. Clifton Coney by a dedication in the upcoming Annual Report. H. DuShane reminded the Society that long time member Leroy Poorman also passed away in the past year, and should also be remembered in the Annual Report.

Outgoing President Eernisse thanked the many persons who assisted him in putting on a great meeting while residing in far away Michigan, and then graciously passed the WSM gavel to President-Elect Kirstie L. Kaiser.

There being no further business, the meeting was adjourned at 5:03 p.m. by President-Elect Kaiser.

Respectfully submitted by George L. Kennedy, Acting Secretary



Front row (left to right): Edna Naranjo-Garcia, Kirstie Kaiser, Doug Eernisse, Nora Foster

Second row: John Jackson, Ellen Jackson, Barry Wilson, Henry Chaney, Kateri Hoekstra, Maria Diupotex, Margaret Mulliner, Charlotte Norrid, Ellinor Michel, Katherine Stewart, David Woodruff, David Mulliner

Third row: Louise Page, Anne Joffee, Megan Lilly, Saxon Sharpe, LouElla Saul

Fourth row: Walter Sage, Carole Hertz, Richard Saul, Paul Scott, Hal Norrid

Back row: Neil Fahy, Kelvin Barwick, Jeff Barksdale, Hsiu-Ping Liu, Don Shasky, Gale Sphon, Wendy Koch, Ron Velarde, George Metz, Jules Hertz, Lois Nelson, Hugh Bradner, Bill Emerson, Barbara Chaney, Hans Bertsch, Virginia Upton, Jim McLean, Carol Skoglund, Bob Koch, Paul Skoglund, Wes Farmer, Al Steinman

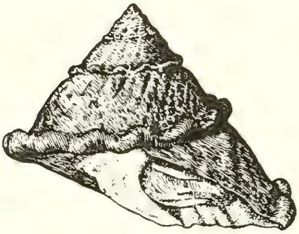
WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1992 - 30 September 1993

INCOME

Membership dues	$1876.00	
Student grant donations (1992)	375.00	
Symposium fund	321.00	
Interest on savings accounts	414.01	
Auction and reprint sales	2065.43	
Miscellaneous income	70.00	
1993 Conference	4067.00	
TOTAL INCOME during period		**$9,188.44**

EXPENSES

Annual report	$1270.25	
Cumulative 25 Year Index	1053.11	
Memberships and fees	47.00	
Reimbursements to officers	175.90	
1993 Student grant	300.00	
1993 Symposium expenses	563.00	
1993 Conference	3417.45	
1994 Meeting advance deposit	200.00	
TOTAL EXPENSES during period		**$7,026.71**
Net gain for period		2,161.73
Beginning balance (1 October 1992)		11,680.90
NET WORTH on 1 October 1993		**$13,842.63**



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THE WESTERN SOCIETY OF MALACOLOGISTS

ANNUAL REPORT
VOLUME 27

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The Western Society of Malacologists

Annual Report

Volume 27

Abstracts and Proceedings of the
Annual Meeting
Held at the Miramar Hotel
Santa Barbara, California
26 - 29 June 1994

Issued:
31 October 1995

Editorial Board, Volume 27
Hans Bertsch, Editor-in-Chief
Paul H. Scott, Production Editor

The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the Annual Report is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $15.00 for regular members, $17.00 family, and $6.00 student.

The Western Society of Malacologists has issued three **Occasional Papers** - No. 1, "'Sea Shells of the Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan; and No. 3, "Twenty-five Year Index to Publications of the Western Society of Malacologists: Author, Taxonomic, Geographic and Subject Indices," by Hans Bertsch.

Correspondence regarding membership and orders for additional or back issues of the **Annual Report** or the **Occasional Papers** should be addressed to the current W.S.M. Treasurer, Dr. George Metz, 121 Wild Horse Valley Drive, Novato, CA 94947 USA.

In Memoriam

Walter D. Sage, New York City, New York
Kay Cummingham Vaught, Scottsdale, Arizona

INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8 1/2" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Chair, Department of Mathematics & Natural Sciences, National University, 4125 Camino del Rio South, San Diego, CA 92018 USA.

ACKNOWLEDGMENTS: This report was produced utilizing the desktop publishing facilities at the Santa Barbara Museum of Natural History.

This publication is printed entirely on recycled paper.

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2 Progress toward Revision of the Liotiinae and Colloniinae of the World. JAMES H. MCLEAN

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Conveners: Terrence M. Gosliner and Henry W. Chaney

This Symposium honors the ongoing contributions to the study of biogeography by **William K. Emerson** of the American Museum of Natural History, New York

3 Pacific Island Biogeography: Myths of the Past, Visions for the Future. E. ALISON KAY

3 Species Richness and Shell Shape in the Hawaiian Land Snail Fauna. ROBERT H. COWIE

3 Biogeography of Opisthobranchs from Offshore Islands in the Eastern Pacific. TERRENCE M. GOSLINER

4 The Molluscan Fauna of Clipperton Island: A Preliminary Report of the 1994 Clipperton Expedition. HENRY W. CHANEY

4 Biogeographic Microcosms: Ecological Contrasts and Variations in Long-Term Regional Faunal Studies (Gulf of California, Mexico). HANS BERTSCH

5 The Molluscan Fauna of the Northeastern Chukchi Sea. NORA R. FOSTER

5 Jurassic and Cretaceous Biogeography of the Superfamily Cypraeoidea. LINDSEY T. GROVES

5 The Biogeographic Significance of *Cypraea* (*Muracypraea*) in the Pliocene Imperial Formation of California. TERRY S. ARNOLD

8 Paleoclimatic and Biogeographic Inferences from Stable Isotope and Community Analysis of Great Basin Land Snails. SAXON E. SHARPE, JOSEPH F. WHELAN, RICHARD M. FORESTER, MARTIN R. ROSE, AND RICHARD J. MOSCATI

CONTRIBUTED PAPERS AND POSTERS

8 Morphology, molecules, and the origin of molluscs. DOUGLAS J. EERNISSE

9 Biology and Behavior of *Grimpoteuthis* off California (Cephalopoda: Cirroctopoda). F. G. HOCHBERG, G. VAN DYKHUIZEN, AND J. STEIN HUNT

9 Muricacean? gastropods of Late Cretaceous (Turonian) age from the Santa Ana Mountains, California. LOUELLA R. SAUL

12 Tale of the Carpenter's Square. EUGENE V. COAN

12 West Coast Cenozoic Marine Molluscan Paleontologists: The First 100 years. RICHARD L. SQUIRES

13 The Atlantid Heteropod's "Spermatophore": Is It or Is It Not? ROGER R. SEAPY

13 Prey selection between co-occurring species of *Turritella* by drilling gastropods in the Gulf of California. DEBRA S. TULL

13 Shell Ultrastructures in Major Gastropod Clades. CLAUS HEDEGAARD and DAVID R. LINDBERG

14 Environmental Scanning Electron Microscopy (ESEM) Applied to Mollusks. CLAUS HEDEGAARD and CHRISTOPHER MEYER

14 Effects of Organic Enrichment on Molluscan Distribution and Abundance on the Mainland Shelf off of San Diego. MEGAN B. LILLY

14 Phylogeny of the Columbellidae (Gastropoda: Neogastropoda): Progress Toward a New Synthesis. MARTA J. DE MAINTENON

14 A Possible Cause for Cypraeid Melanism in New Caledonia. CHRISTOPHER MEYER

15 Invertebrates Associated with Land Shells. EDNA NARANJO-GARCIA

17 Parasites as an Aid to Research on Short-finned Squid Biology and Fisheries in Spain. SANTIAGO PASCUAL

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17 Collecting Landsnails in the Bahamas, 1994. NEIL E. FAHY

18 Chromosomes of the Freshwater Clam *Anodonta chapalensis* Crosse and Fisher, 1892, from Michoacan, Mexico. MARÍA E. DIUPOTEX and M. LOURDES MARTÍNEZ ORTÍZ

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SYSTEMATICS OF MICROMOLLUSKS SYMPOSIUM

Convener:
James H. McLean
Natural History Museum of Los Angeles County

INTRODUCTION AND OVERVIEW

James H. McLean
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Most large-shelled families of mollusks are now reasonably well known, but many of those attaining sizes under 8 mm are poorly understood. Large numbers of species in many families, particularly those from the tropical Pacific remain to be described. Single areas in the tropics can yield over 500 species of micromollusks, many more species than those over 8 mm.

Early work on micromollusks relied mostly on drawings of shells, some very crudely drawn, but more recent work has greatly benefited from the use of the scanning electron microscope, making it possible to look at protoconch sculpture, shell microscultpure, and radular morphology, details that are barely discernible under the dissecting microscope. There is not one general book that serves as a guide to all the small-shelled genera of all families, a gap that may take a long time to be filled. The reason for this inconvenient lack of a general reference is that those who study micromollusks limit their studies to single families or groups of related families. Even for specialists, the families are so large that most papers are faunal in scope, with very few worldwide revisions. One encouraging trend is that specialists have begun to treat genera family by family, reviewing each type species, making it possible for those with regional interests to proceed.

To my knowledge this is the first symposium and workshop ever offered in which the unifying theme is the small size of the mollusks under study.

COLLECTING MICROSCOPIC MOLLUSKS

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During the past 26 years I have used several methods of shaking substrates for collecting microscopic species. As a result a great variety of species, huge numbers of specimens and many undescribed taxa have been collected, including a high percentage of living material, which has allowed for anatomical study.

The shaking of substrates into containers is equally effective whether one is working intertidally or at SCUBA depths. It can also be used to dislodge micromollusks that are carried from deeper waters during dredging or trawling. For intertidal work a plastic bucket, partially filled with water is the most efficient receptacle in which rocks and algae can be agitated. For work in deeper water the use of a heavy duty canvas bag is preferable. These bags are sold by dive shops as large size "goody bags" for use in collecting lobster and abalone. The top of the bag is opened or closed by a hinged metal ring, while the bottom of the bag has a mesh bottom which must be removed and stitched shut by a canvas maker.

Into the bag one shakes anything and everything, particularly rocks, dead coral heads, rubble, algae or wood fragments. At the end of the dive, material is emptied into trays where it is washed and screened, prior to sorting. The more active species can often be observed at this point as they begin to crawl up the sides of the washing trays.

METHODS OF COLLECTING AND HANDLING MARINE MICROMOLLUSKS

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The first requirement for study of micromollusks is a good binocular dissecting microscope. Collecting involves taking samples of the substrate, by hand or using a net or hand dredge, or shaking of algae or stones in a basin or bag to dislodge the specimens. Recovery of specimens from bottom samples is made easier with screens of decreasing sizes so that specimens of similar size are handled together. Washing the sample before picking or washing the extracted specimens before sorting is an important step because salt residue will eventually lead to the dissolution of the shell. For permanent storage, specimens can be placed in gelatin capsules with vials or plastic boxes, in small glass vials within larger glass vials, or in cardboard micromounts with sliding plastic covers, the label affixed to the back side of the mount.

WHAT IS A MICROMOLLUSC?

Anders Warén
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A short review is given of the minimum size of mollusc groups and it is pointed out that there is a great geographic variation in the minimum size of gastropods. After this I will concentrate on the morphology and ecology of small gastropods, to show that small size leads to convergences in several features. I will then try to give some support for my view that some of the taxa of very small gastropods with large morphologic variation have evolved independently and that these taxa are polyphyletic. I will also discuss my belief that evolution towards small size among gastropods is an evolutionary "cul de sac."

THEY ALL LOOK THE SAME! — CONVERGENCE IN SHELL FORM IN MICRO-GASTROPODS

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The study of several groups of micro-gastropods has proved difficult because of their often simple shells and the high degree of convergence in shell form encountered. A classic example in convergence in shell morphology across many groups of gastropods is that of limpet shape. As with limpets, the correct placement of many taxa with simple coiled shells often necessitates studies on the external morphology of the animal and anatomy as well as examination of the radula and operculum. However, once well founded groups become established detailed examination of shells, particularly protoconchs, can sometimes provide reliable information. Examples are given to illustrate the convergence in "skeneiform" or "vitrinelliform" shells, a shell shape (depressed "trochiform") which appears in most major gastropod groups. Examples from rissoid-like (simple conical) shells are also given. Considering how many gastropods with small, simple shells are still only known from their shells, many more examples of unexpected convergence undoubtedly remain to be uncovered.

CAECIDAE OF THE INDO-PACIFIC AND EASTERN PACIFIC

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Slides are shown of representative species of Caecidae from the eastern Pacific, including the northern, tropical, and southern regions, and from the Indo-Pacific. Most species in the Indo-Pacific are broadly distributed. Although Hawaii has fewer species than those of the western Pacific, those of Hawaii are not endemic.

PROGRESS TOWARD REVISION OF THE LIOTIINAE AND COLLONIINAE OF THE WORLD

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Liotiinae and Colloniinae are basal subfamilies of Turbinidae in which the radular plan is plesiomorphic, with few distinctions at the generic and specific level yet recognized in either group. Opercula differ widely; the multispiral operculum of Liotiinae is ornamented with external calcareous beads, whereas that of Colloniinae is enveloped by the foot and thickened externally with calcareous deposits. Species of a few genera in each group brood the young in the umbilical cavity, which is larger in females than males in such genera. Both groups exhibit size extremes ranging from maximum dimensions of 1 mm to 30 mm, although many are under 5 mm, which qualifies most as microgastropods.

Although opercula are rarely prserved as fossils, the liotiine genera with characteristic lamellar sculpture and thickened lips have been recognized in the Permian and through the Mesozoic. Shell characters of Colloniinae are approached in other trochacean groups and the origin is murky, like that of most Trochacea.

I have been gathering materials toward complete monographs of these two groups for many years. Specific names have been tracked in the literature and nearly all the type specimens have been photographed. Collections of the major museums have been studied. Manuscript names for the new species have been chosen and generic diagnoses are now in draft but much work remains.

At this time I recognize a total for both subfamilies of 47 genera, of which 18 are new, and 326 living species, of which 139 are new. Previously described species total 187 and have 96 synonyms, a relatively low synonymy ratio of 1.51. The high number of new species (42% of those living) derives from the fact that most species are small and usually overlooked and that many have very limited distributions, a correlation with the short planktonic life of broadcast-spawning archaeogastropods.

Forty seven species (34% of those new) were recognized in the LACM collection, a result of efforts of volunteers in extracting specimens from sediments samples collected by divers in many areas of the world.

CURRENT TOPICS IN THE BIOGEOGRAPHY OF MOLLUSKS SYMPOSIUM

Conveners:

Terrence M. Gosliner
California Academy of Sciences

Henry W. Chaney
Santa Barbara Museum of Natural History

THIS SYMPOSIUM HONORS THE ONGOING CONTRIBUTIONS TO THE STUDY OF BIOGEOGRAPHY BY

WILLIAM K. EMERSON

of the
American Museum of Natural History, New York

PACIFIC ISLAND BIOGEOGRAPHY: MYTHS OF THE PAST, VISIONS FOR THE FUTURE

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The facts associated with biogeography in the Pacific basin are well known. There are perhaps 10,000 islands in the tropical Pacific between the Indo-Malayan archipelago and the west coast of the Americas. They occur as high volcanic islands, nearly sea-level atolls, and guyots and sea mounts thousands of meters below sea level. They range in age from literally hours to more than 70my. At least seven times during the past 2my drops in sea level between 100 and 150 meters have stranded much of the shallow water shelf environment. This ocean of islands is a region of great biological diversity seemingly centered on the Indo-Malayan archipelago, and attenuating to the east. A variety of dispersal mechanisms are known: currents, planktonic veliger larvae of mollusks, eggs and larvae of fish, rafting for corals.

Despite more than a century of description and maps of species distributions, mechanisms underlying the origins of that diversity are not clear. How do populations of corals and mollusks and fish become isolated and diverge when long-lived larval stages provide the potential for gene flow and dispersal? Attenuation implies barriers to dispersal, but some species are distributed continuously from East Africa to Hawaii, even to the west coast of the Americas, yet their distribution is not clearly correlated with length of larval life. The explanations of the past are our myths: why not a continent? dispersal? vicariance? long term stable environment? Visions for the future may lie in some recent work: the occurrence of hidden species, DNA sequence data, and reconsideration of the possible results of hybridization.

SPECIES RICHNESS AND SHELL SHAPE IN THE HAWAIIAN LAND SNAIL FAUNA

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The native land snail fauna of the Hawaiian islands consists of over 750 described nomenclaturally valid species. Species richness on each island is strongly correlated with island area, age, maximum altitude and habitat diversity, but only poorly with the island's distance from a source of colonization. Path analysis allowed the direct and indirect influences of these factors on species richness to be disentangled. Species richness is related to evolutionary radiation and not to the classic equilibrium theory of a balance between immigration and extinction. Path analysis also indicated a strong effect of differential collecting effort on each island.

Shell shape variation within the Hawaiian fauna, as analyzed in terms of spire index (shell height/width), follows the general bimodal pattern seen in most land snail faunas, with tall thin species and flat or squat species predominating, there being few globular or equidimensional species. Ecological rather than taxonomic reasons probably underlie this pattern.

BIOGEOGRAPHY OF OPISTHOBRANCHS FROM OFFSHORE ISLANDS IN THE EASTERN PACIFIC

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Recent collections of opisthobranch gastropods from the Revillagigedos Islands, Clipperton Island, Cocos Island, the Gulf of Chiriqui and the Galápagos have provided a wealth of new records and have added to our knowledge of the opisthobranch fauna of the eastern Pacific. These collections provide new data for estimating overall opisthobranch diversity in the eastern Pacific as well as expanding our understanding of distribution patterns within the region. Revised estimates of Indo-Pacific influence and degree of endemism are presented in light of new evidence. The Galápagos Archipelago represents a region of relatively high endemism within the Panamic Biogeographical Province.

THE MOLLUSCAN FAUNA OF CLIPPERTON ISLAND: A PRELIMINARY REPORT OF THE 1994 CLIPPERTON EXPEDITION

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During April of 1994 a detailed survey of the marine mollusks of Clipperton Island was undertaken as part of a two week expedition to this remote atoll in the eastern Pacific. This survey was the first detailed examination since the Scripps Institution expeditions of the late 1950's (during which mollusks were collected somewhat incidentally) and the first ever to concentrate on collecting in the SCUBA zone down to 35 m. During the course of our visit, five members of the expedition logged over 160 hours of diving for mollusks and virtually all parts of the island were examined.

The preliminary results of our survey confirm previous reports that the diversity of mollusk species is much lower than any other oceanic island in the eastern Pacific, but that there is almost an equal number of species being derived from the Indo-Pacific as from the Panamic faunal province. A significant number of new records of occurrence have been compiled, with the majority of these species being micromollusks. There was also ample evidence of transient species, whose dead and eroded shells were found, without any living representatives.

BIOGEOGRAPHIC MICROCOSMS: ECOLOGICAL CONTRASTS AND VARIATIONS IN LONG-TERM REGIONAL FAUNAL STUDIES (GULF OF CALIFORNIA, MEXICO)

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In several recent publications (Bertsch, 1991, 1993) I have studied the biogeography and biodiversity of the eastern Pacific. I have examined faunal relationships with other regions, and compared the taxonomic diversity of nudibranchs in the temperate NE Pacific with the tropical Panamic provinces. As more data are collected, and species are discovered, these data will change—primarily adding more species to the known Panamic province. Species collected only once will forever be on the list of "shared species," indicating faunal relationships.

Here lies the problem I address in this note. Faunal affinities between zoogeographical provinces have often been based on relatively few specimens of species shared between areas.

Biogeographic studies should take into account short- and long-term temporal and geographic variations, including comparisons of relative abundance. This struck me 25 years ago, when I first reported the presence of the Indo-Pacific species *Dolabrifera dolabrifera* in the southern Gulf of California, based on only one specimen. To my knowledge, it has not been reported since from Pacific Mexican coasts nor the Gulf of California. However 5 years after publishing my report, *Dolabrifera* was so common in Panama that I was slipping on them in the tidepools!

Long-term patterns of variation in small geographic regions can contribute significantly to our understanding of distributional patterns and interactions among larger biogeographic regions (i.e., within large enclosed seas, or between faunal provinces).

I am conducting a long-term natural history study of opisthobranch mollusks on the reefs at Punta La Gringa and Cuevitas, in Bahía de los Angeles, Baja California, Mexico. During the past 3 years I have measured and identified 3056 specimens, belonging to 62 species.

Major new data include at least 10 undescribed species, range extensions, feeding records, reproductive behavior, and seasonal and bathymetric variations. Distribution patterns of the species exhibit the expected extremes: species common year round; species present year round, but in low numbers; those with high numbers based on a single very large collecting sample; the rare ones; and those cryptic species we're lucky to find.

Among the 15 most common species, are the following provincial affinities:

7 are Panamic endemics;
2 are Caribbean;
1 is Indo-Pacific;
5 are Californian;
4 are unnamed species (including 4 Panamic endemics and 1 Californian).

Many biogeographical changes occur on time spans far greater than human life spans or recorded scientific investigations. Witness the *Acanthaster planci* fluctuations and questions about frequency of coral reef destruction by El Niño episodes.

Recent papers by Jackson (1994) and Buzas & Culver (1994) have discussed biotic faunal exchange over time scales of millions of years. Paleontological evidence (lacking for nudibranchs) shows changes over time and location in both distribution and abundance patterns. Using "historical" data samples, Grabherr et al. (1994) report similar, but on a much smaller scale, biotic variation (slight temperature differences responsible for vertical plant migration over a 100 year time span).

My studies at Bahía de los Angeles, coupled with others throughout southern California and the Panamic province, are an attempt to understand changes over time, regional variations, and the relationships between different relative abundances of shared species in a biogeographical context.

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THE MOLLUSCAN FAUNA OF THE NORTHEASTERN CHUKCHI SEA

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Studies of the oceanography of the eastern Chukchi Sea between Point Hope and Point Barrow have resulted in large well-documented collections of mollusks from the area. A recent publication (Feder et al., 1994) on the NE Chuckchi Sea mollusks, describes the occurrence of 139 taxa and relates distribution abundance, and biomass to the area's oceangraphy: sediments, POC, temperature and salinity of the water, and especially to a bottom front between water masses.

The distribution of 108 mollusks from the northeastern Chukchi Sea were considered in this analysis. The species list prsented here (Table 1, pgs. 6-7) differs slightly from the list of taxa included with Feder et al. (1994), because it eliminates questionable identifications, identifications made only to the generic level, and includes a few species that were collected as part of other studies. Taxa for which identification problems make determination of their biogeographic affinities impossible were likewise not included. Examples include several species of *Alvania*, *Velutina*, *Oenopota*, and *Buccinum*.

The largest number of species, 47, are Boreal-Arctic. Pacific-Boreal species, for which the Chukchi/Beaufort sea is the northern end of thir distribution, make up one third of the species, 36. Twelve species are known from the boreal Pacific, and the Arctic. A smaller number, 10 are amphiboreal. Pacific-Boreal species include fourteen limited to Alaskan waters or the Aleutian province. Nine species are known from the western Pacific Ocean, but not from the Eastern Pacific south or east of the western Gulf of Alaska.

Golikov and Scarlato (1989) show the area from Norton Sound through Bering Strait to Point Barrow, as an ecotone between boreal and arctic waters. The NE Chukchi Sea is also an area of overlap between eastern and western Pacific molluscan fauna.

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JURASSIC AND CRETACEOUS BIOGEOGRAPHY OF THE SUPERFAMILY CYPRAEOIDEA

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Latest Jurassic and Cretaceous cypraeacean gastropods comprise at least 67 species from Europe, China, India, North America, Brazil, and northern and southern Africa. The earliest cypraeaceans *Palaeocypraea (Palaeocypraea) tithonica* (Stefano, 1882) and *Bernaya (Bernaya) gemmellaroi* (Stefano, 1882) appeared in latest Jurassic (Tithonian) strata of Sicily, Italy. At least seven species are known from Early Cretaceous (Barremian through Albian) strata, 18 species are known from from early Late Cretaceous (Cenomanian through Coniacian) strata, and 40 species are known from latest Cretaceous (Campanian through Maastrichtian) strata. The Campanian/ Maastrichtian is the Mesozoic cypraeacean peak in terms of both numbers of species and geographic distribution. Across the K/T boundary only 11 early Paleocene (Danian) cypraeacean species are known from strata in Northern Europe, Iran, and Madagascar.

THE BIOGEOGRAPHIC SIGNIFICANCE OF *CYPRAEA (MURACYPRAEA)* IN THE PLIOCENE IMPERIAL FORMATION OF CALIFORNIA

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The cypraeid subgenus *Muracypraea* Woodring, 1957 occurs in Miocene-lower Pliocene deposits throughout the Caribbean region (Dominican Republic, Venezuela, Costa Rica, Panama, Ecuador). It is represented in the Recent by one or two recent species, *Cypraea (Muracypraea) mus* Linnaeus, 1758 and *C. (M.) donmoorei* Petuch, 1979, confined to Venezuela and eastern Columbia. Reports of *Muracypraea* on the Pacific coast of the Americas have been limited to the Miocene Isidro formation of southern Baja California, Mexico, *Cypraea amandusi* Hertlein & Jordan, 1927, and an unconfirmed report of *C. amandusi* in the lower Pliocene strata of the Imperial Formation of Imperial County, California. Recently a specimen, from lower Pliocene Imperial Formation strata of Fossil (Alverson) Canyon, Imperial County, California, came to light which has strong affinities to the Recent *Muracypraea* species. This confirmed report is the farthest north occurrence of this subgenus throughout its entire

continued on Page 8

Table 1. Biogeographic affinities of NE Chukchi Sea mollusks

Gastropoda

Lepetidae	1. *Lepeta caeca* (Müller, 1776)	Boreal-Arctic
Lottiidae	2. *Tectura testudinalis* (Müller, 1776)	Boreal-Arctic
Trochidae	3. *Margarites argentatus* (Gould, 1841)	Boreal-Arctic, Pacific
	4. *Margarites costalis* (Gould, 1841)	Boreal-Arctic
	5. *Margarites giganteus* (Leche, 1878)	Boreal-Arctic, Pacific
	6. *Margarites vahlii* (Müller, 1842)	Boreal-Arctic
	7. *Margarites vorticifer* (Dall, 1873)	Pacific-Boreal
	8. *Solariella obscura* (Couthouy, 1838)	Boreal-Arctic
	9. *Solariella varicosa* (Mighels and Adams, 1842)	Boreal-Arctic
Turbinidae	10. *Moelleria costulata* (Müller, 1842)	Boreal-Arctic
Littorinidae	11. *Littorina squalida* Broderip and Sowerby, 1829	Pacific-Boreal
Turritellidae	12. *Tachyrhynchus erosus* (Couthouy, 1838)	Boreal-Arctic
	13. *Tachyrhynchus reticulatus* (Mighels and Adams, 1842)	Boreal-Arctic
Epitoniidae	14. *Boreoscala greenlandica* (Perry, 1811)	Boreal-Arctic
Calyptraeidae	15. *Crepidula grandis* (Middendorff, 1849)	Pacific-Boreal
Trichotropidae	16. *Trichotropis bicarinata* (Sowerby, 1825)	Amphiboreal
	17. *Trichotropis borealis* Broderip and Sowerby, 1829	Amphiboreal
	18. *Trichotropis coronata* Gould, 1860	Boreal-Arctic, Pacific
	19. *Trichotropis kroyeri* Philippi, 1848	Amphiboreal
	20. *Trichotropis peramabilis* (Dall, 1871)	Pacific-Boreal
Naticidae	21. *Amauropsis islandica* (Gmelin, 1791)	Boreal-Arctic
	22 *Bulbus fragilis* (Leach, 1819)	Amphiboreal
	23. *Natica clausa* Broderip and Sowerby, 1829	Boreal-Arctic
	24. *Polinices pallidus* (Broderip and Sowerby, 1829)	Boreal-Arctic
Lamellariidae	25. *Capulacmaea commoda* Middendorff, 1851)	Boreal-Arctic
	26. *Marsenina glabra* (Couthouy, 1832)	Boreal-Arctic
	27. *Velutina undata* (Brown, 1839)	Boreal-Arctic
Muricidae	28. *Boreotrophon beringi* Dall, 1902	Pacific-Boreal
	29. *Boreotrophon muriciformis* (Dall, 1877)	Boreal-Arctic, Pacific
	30. *Nucella lima* (Gmelin, 1791)	Pacific-Boreal
Buccinidae	31. *Beringius beringii* (Middendorff, 1848)	Boreal-Arctic, Pacific
	32. *Beringius stimpsoni* (Gould, 1860)	Pacific-Boreal
	33. *Buccinum angulosum* Gray, 1939	Pacific-Boreal
	34. *Buccinum ciliatum* Fabricius, 1780	Boreal-Arctic
	35. *Buccinum plectrum* Simpson, 1865	Boreal-Arctic, Pacific
	36. *Buccinum polare* Gray, 1839	Boreal-Arctic, Pacific
	37. *Buccinum scalarifrome* Müller, 1842	Boreal-Arctic
	38. *Clinopegma magna* (Dall, 1895)	Pacific-Boreal
	39. *Colus dautzenbergi* Dall, 1816	Boreal-Arctic
	40. *Colus ombronius* (Dall, 1919)	Pacific-Boreal
	41. *Colus hypolispus* Dall, 1891	Pacific-Boreal
	42. *Colus roseus* (Dall, 1877)	Boreal-Arctic, Pacific
	43. *Colus spitzbergensis* (Reeve, 1855)	Amphiboreal
	44. *Liomesus ooides* (Middendorff, 1849)	Pacific-Boreal
	45. *Neptunea borealis* (Philippi, 1850)	Boreal-Arctic, Pacific
	46. *Neptunea heros* Gray, 1850	Boreal-Arctic, Pacific
	47. *Neptunea ventricosa* (Gmelin, 1791)	Boreal-Arctic, Pacific
	48. *Plicifusus callorhinus* (Dall, 1877)	Pacific-Boreal
	49. *Plicifusus kroyeri* (Müller, 1842)	Boreal-Arctic
	50. *Volutopsous attenuatus* (Dall, 1874)	Pacific-Boreal
	51. *Volutopsius deformis* (Reeve, 1847)	Boreal-Arctic, Pacific
	52. *Volutopsius fragilis* (Dall, 1891)	Pacific-Boreal
	53. *Volutopsius stefanssoni* Dall, 1919	Pacific-Boreal
Cancellarridae	54. *Admete couthouyi* (Jay, 1839)	Boreal-Arctic
	55. *Admete regina* Dall, 1919	Pacific-Boreal

Turridae	56. *Oenopota harpa* (Dall, 1855)	Pacific-Boreal
	57. *Oenopota turricula* (Montagu, 1803)	Boreal-Arctic
	58. *Oenopota simplex* (Middendorff, 1849)	Pacific-Boreal
Retusidae	59. *Retusa obtusa* (Montagu, 1803)	Amphiboreal
Scaphandaridae	60. *Cylichna alba* (Brown, 1827)	Amphiboreal
	61. *Cylichna occulta* (Mighels, 1841)	Boreal-Arctic
Calycidoridae	62. *Calycidoris geuntheri* Abraham, 1876	Boreal-Arctic
Tritoniidae	63. *Trochuina tetraquetra* (Pallas, 1788)	Pacific-Boreal

Bivalvia

Nuculidae	64. *Nucula tenuis* (Montagu, 1808)	Boreal-Arctic
Nuculanidae	65. *Nuculana minuta* (Fabricius, 1776)	Boreal-Arctic
	66. *Nuculana radiata* (Krause, 1885)	Boreal-Arctic
Yoldiidae	67. *Yoldia amygdalea* (Valenciennes, 1846)	Boreal-Arctic
	68. *Yoldia myalis* (Couthouy, 1838)	Amphiboreal
	69. *Yoldia scissurata* (Dall, 1897)	Pacific-Boreal
Mytilidae	70. *Musculus discors* (Linnaeus, 1767)	Boreal-Arctic
	71. *Musculus niger* (Gray, 1824)	
Pectinidae	72. *Chlamys behringiana* (Middendorff, 1849)	Pacific-Boreal
Anomiidae	72. *Pododesmus macroschisma* (Deshayes, 1839)	Pacific-Boreal
Thyasisidae	73. *Thyasira gouldii* (Philippi, 1845)	Boreal-Arctic
Ungulinidae	74. *Diplodonta aleutica* Dall, 1901	Pacific-Boreal
Montacutidae	75. *Mysella planata* (Krause, 1885)	Pacific-Boreal
	76. *Mysella tumida* (Carpenter, 1864)	Pacific-Boreal
Astartidae	77. *Astarte borealis* (Schumaker, 1817)	Boreal-Arctic
	78. *Astarte montagui* Dillwyn, 1817	Boreal-Arctic
Carditidae	79. *Cyclocardia crassidens* (Broderip and Sowerby, 1829)	Pacific-Boreal
	80. *Cyclocardia crebricostata* (Krause, 1885)	Pacific-Boreal
	81. *Cyclocardia ovata* (Rjabinina, 1952)	Pacific-Boreal
Cardiidae	81. *Clinocardium californiense* (Deshayes, 1839)	Pacific-Boreal
	82. *Clinocardium ciliatum* (Fabricius, 1780)	Boreal-Arctic
	83. *Serripes groenlandicus* (Bruguière, 1789)	Boreal- Arctic
	84. *Serripes laperousii* (Deshayes, 1839)	Pacific-Boreal
Tellinidae	85. *Macoma balthica* (Linnaeus, 1758)	Boreal-Arctic
	86. *Macoma calcarea* (Gmelin, 1791)	Boreal-Arctic
	87. *Macoma lama* Bartsch, 1929	Pacific-Boreal
	88. *Macoma loveni* (A. S. Jensen, 1905)	Boreal-Arctic
	89. *Macoma middendorffi* Dall, 1884	Pacific-Boreal
	90. *Macoma moesta* (Deshayes, 1855)	Boreal-Arctic
	91. *Tellina lutea* Wood, 1828	Boreal-Arctic, Pacific
Veneridae	92. *Liocyma fluctuosa* (Gould, 1841)	Boreal-Arctic
Mactridae	93. *Mactromeris polynyma* (Stimpson, 1860)	Amphiboreal
Cultellidae	94. *Siliqua alta* (Broderip and Sowerby, 1827)	Pacific-Boreal
Myidae	95. *Mya pseudoarenaria* Schlesch, 1931	Amphiboreal
	96. *Mya truncata* Linnaeus, 1758	Boreal-Arctic
Haitellidae	97. *Cyrtodaria kurriana* Dunker, 1862	Boreal-Arctic
	98. *Hiatella arctica* (Linnaeus, 1767)	Boreal-Arctic
	99. *Panomya arctica* (Lamark, 1818)	Boreal-Arctic
Lyonsiidae	100. *Lyonsia arenosa* (Müller, 1842)	Boreal-Arctic
Pandoridae	101. *Pandora glacialis* Leach, 1819	Boreal-Arctic
Thraciidae	102. *Thracia devexa* G. O. Sars, 1878	Boreal-Arctic
	103. *Thracia myopsis* Müller, 1842	Boreal-Arctic
	104. *Lampeia adamsi* (MacGinitie, 1959)	Pacific-Boreal
Periplomatidae	105. *Periploma aleuticum* (Krause, 1885)	Pacific-Boreal
Pholadidae	106. *Zirphaea pilsbryi* Lowe, 1931	Pacific-Boreal

Polyplacophora

Ischnochitonidae	107. *Stenosemus albus* (Linnaeus, 1767)	Boreal-Arctic
Mopaliidae	108. *Amicula vestita* (Broderip and Sowerby, 1829)	Boreal-Arctic

historic range and the most recent outside of the Caribbean region. The nearest occurrence of related species in the Pacific are *Cypraea caputviperae* Martin, 1899, *C. murisimilis* Martin, 1879, and *C. beberkiriana* Martin, 1899 from the Miocene of Java. The absence of reports of any related species from the Pacific islands and the direct development propagation mode of the Recent species lends support for the hypotheses that *Muracypraea* spread to the Pacific coast through the Isthmus of Panama prior to its closure in the middle-late Pliocene. The strong Caribbean affinities of the Imperial Formation corals and other gastropod fauna has been reported previously, providing further support for this hypothesis.

PALEOCLIMATIC AND BIOGEOGRAPHIC INFERENCES FROM STABLE ISOTOPE AND COMMUNITY ANALYSIS OF GREAT BASIN LAND SNAILS

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Terrestrial and aquatic molluscs uptake local water during their growing season (spring and summer) and incorporate its 18O isotopic signature into their shells. Preliminary 18O analysis of modern shells from the southern Great Basin indicates that the shells probably reflect meteoric water 18O values during their growing seasons. This provides a way to estimate the delta 18O value of precipitation and from that the source of moisture-producing air masses. Nonparametric and parametric statistical and graphic analyses preliminarily assess the major sources of variability in the delta 18O molluscan dataset.

Significant 18O variability in modern shells analyzed include geographic location, elevation, taxonomy, and habitat (terrestrial, spring, or wetland). Delta 18O values of modern and fossil shells are also very different; modern values in this location are much higher than those from nearby late Pleistocene molluscs suggesting that the Pleistocene summers were variously colder and wetter than today or less evaporative (more humid). Assuming shell material directly reflects the 18O of the growing-season environment, comparison of modern and fossil shell delta 18O values can potentially identify changes in air mass-moisture sources and can help to define seasonal precipitation change through time. Comprehension and quantification of community and isotopic variability in modern gastropods is required to create probabilistic valid transfer functions with fossil materials. Valid inferences about past environmental conditions can then be established with known confidence limits.

CONTRIBUTED PAPERS AND POSTERS

MORPHOLOGY, MOLECULES, AND THE ORIGIN OF MOLLUSCS

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Molluscs are clearly protostome metazoans, but the precise pattern of branching among the protostome phyla has remained controversial. Recent cladistic analyses based on morphological characters (Eernisse, Albert, and Anderson, 1992) have supported a grouping, Eutrochozoa, composed of molluscs, annelids, pogonophorans, sipunculans, echiurans, and nemerteans. This view is contrary to the conventional grouping of annelids and arthropods. Previous 18S ribosomal RNA (rRNA) sequence comparisons have already indicated tentative support for the Eutrochozoa hypothesis, but these analyses were limited by patchy taxonomic sampling and incomplete sequences for certain taxa. In collaboration with Gi-Sik Min, Sang Hee Kim, and Won Kim, we have added several new protostome complete 18S rRNA sequences, and have analyzed these as aligned with other available metazoan 18S rRNA sequences, including both protostome and other metazoan representatives. Our new sequences include two polychaetes, a pogonophoran, a sipunculan, an echiuran, and acanthocephalan, two tardigrades, a pycnogonid, an onychophoran, a decapod crustacean, a pentastomid, two centipedes, an inarticulate brachiopod, and an articulate brachiopod. Our analyses strongly support the Eutrochozoa hypothesis, and also suggest a close affinity between eutrochozoans and brachiopods.

BIOLOGY AND BEHAVIOR OF *GRIMPOTEUTHIS* OFF CALIFORNIA (CEPHALOPODA: CIRROCTOPODA)

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An undescribed species of finned octopod, in the genus *Grimpoteuthis,* routinely has been observed and collected in the eastern North Pacific Ocean off Monterey, California. The small, semigelatinous cirrate appears to be restricted in distribution to the nearshore head of a submarine canyon. *In situ* observations have been recorded on video during dives of a ROV operated by the Monterey Bay Aquarium Research Institute. The envelope of capture can be precisely defined. The octopod lives at depths ranging from 300-400m and typically occurs at altitudes of 1-40m off the bottom. Live animals have been maintained and observed for up to three months in large research tanks at the Monterey Bay Aquarium and the Monterey Bay Aquarium Research Institute.

Almost all life history stages have been observed and/or collected. *In situ* behavior can be compared with aquarium observations: The study of preserved specimens provides insights on growth and coloration changes in cirrate octopods. Gut content studies on recently captured animals indicate a diet of micro-crustaceans and polychaetes. Animals in captivity do not appear to feed and die after a period of several weeks to several months. To date two females have laid eggs in the aquarium.

The ability to repeatedly locate and observe finned octopods in relatively shallow water and then to capture and maintain animals in aquaria may eventually lead to a more complete understanding of the biology and behavior of cirrates.

MURICACEAN? GASTROPODS OF LATE CRETACEOUS (TURONIAN) AGE FROM THE SANTA ANA MOUNTAINS, CALIFORNIA

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Three new species of *Praesargana* Saul and Popenoe, 1993 are the first reported from Southern California. The genus *Praesargana* was proposed for *Trophon condoni* White, 1889 of Turonian age from northern California, and is very similar to *Sargana* Stephenson, 1923; type species *Rapana stantoni* Weller, 1907. All known occurrences of *Praesargana* are of Turonian age and earlier in time than those of *Sargana* which occurs in the Campanian-Maastrichtian of the Atlantic and Gulf Coasts and the Campanian of Pondoland, South Africa. *Sargana* was at first classed as the sole genus in a family Sarganidae, Stephenson, 1923, but recently it has been placed elsewhere (Sohl, 1964; Garvie, 1991; Garvie, 1992; Tracy et al., 1993) (See Table 1, pg. 11). Ponder and Warén (1988) placed the subfamily Sarganinae in the Muricidae Rafinesque, 1815, with a query. With muricids sarganins share ornate sculpture and features of the umbilicus and siphonal canal, but they have a more paucispiral protoconch than early muricids.

In 1952 Stephenson included in Sarganidae two more Late Cretaceous genera, *Schizobasis* Wade, 1916, and *Hillites* Stephenson, 1952. However, in 1964 Sohl, upon studying the Maastrichtian age fauna from the Ripley Formation along Coon Creek, Tennessee, that includes *Sargana* and *Schizobasis,* dissociated *Sargana* from *Schizobasis* and *Hillites* and placed these latter two in the Moreinae Stephenson, 1941. Sohl decided that most features of *Sargana* could be found in *Rapana* Schumacher, 1817 and other Rapaninae Gray, 1853, and he placed *Sargana* in the subfamily Rapaninae of the Muricidae. In their classification of the Caenogastropoda, Ponder & Warén, 1988, resurrected Stephenson's name, but made it a subfamily, Sarganinae, and questionably placed it in the Muricidae. In 1991 Garvie suggested placing *Sargana* in the Trichotropidae Gray, 1850, of the Neotaenioglossa on the basis of its protoconch. The following year, Garvie (1992) indicated that *Sargana* belonged in the Cancellariidae Gray, 1853, of the Neogastropoda but gave no reason for this reallocation. Tracy et al. (1993) suggested that *Lowenstamia* Sohl, 1964, and *Sargana,* which they comment upon under the family Coralliophilidae Chenu, 1859, are possibly neotaenioglossan muricacean homeomorphs. Tracy et al. (1993) appear to be the only authors to link *Sargana* with the coralliophilids. *Sargana* does have a protoconch, anterior canal, and umbilicus similar to that of *Latiaxis serrata* (Wade, 1916). This species, which is also from the Coon Creek fauna, does resemble a *Latiaxis,* and would, therefore, be a coralliophilid. Other species with protoconchs similar to that of sarganins are in the Pyropsidae Stephenson, 1941 or Tudiclidae Cossmann, 1901, particularly species resembling *Pyropsis perlata* (Conrad, 1860), the type species of *Pyropsis* Conrad, 1860. With pyropsids, sarganins share similar sculpture, a paucispiral protoconch, and a single fold on the columella, but they have a wider umbilicus and a narrower anterior canal. The 1988 classification of Ponder & Warén places the Pyropsidae within the superfamily Muricacea.

Sarganinae have a distinctive flattened protoconch, a columellar fold, a very narrow anterior canal, the posterior canal adjacent to the suture, and a moderate to wide umbilicus with a lacinate carina.

Shape, ornament, apertural features, the columellar fold, and the protoconch have been considered by most in allocating the Sarganinae, but the weight given to the features has varied. Shape and ornament are certainly suggestive of Muricidae. The shape of the aperture, the anterior canal, and the structure of the umbilicus are also suggestive of Muricidae. The placement of the posterior canal is possibly more suggestive of pyropsids. The posterior canal of most muricids and coralliophilids is at or near the shoulder, but the posterior canal of pyropsids is at the suture, as is that of sarganids. Trichotropids essentially lack a posterior canal; although in some, the posterior end of the aperture is angulate at the suture. Cancellariids also have a quite different aperture. The anterior canal is wide and the aperture is not rounded. Early cancellariids such as *Paladmete* Gardner, 1916, and *Pleisiotriton* Fischer, 1884 certainly are not similar to sarganins. The columellar fold of *Sargana* and *Praesargana* is similar in placement and inclination to that of pyropsids.

Klaus Bandel (1988) has written warmly of the protoconch as a character that records relationship, is available to paleontologists, and tests proposed phylogenies of Recent gastropods. Protoconchs of Pacific Slope Cretaceous gastropods are difficult to study because the fossils are usually preserved in a rather hard and sandy matrix and the shell is usually recrystallized. Fine details of the protoconch are generally obliterated by recrystallization, leaching, or difficulty in removing well cemented sand grains. The protoconch of *Praesargana condoni* (White, 1889) (type species of *Praesargana)* is of about 2 whorls, low, rapidly expanding, apparently smooth, but becoming carinate (Saul and Popenoe, 1993). The transition from protoconch to teleoconch appears to be unmarked. This protoconch is similar to that of *Sargana*. Kool, 1993, says such protoconchs are usually indicative of crawl-away larvae. Vokes, 1971, has said that early muricids have multispiral protoconchs. Kool, 1993, shows that the Muricinae and Rapaninae have multispiral protoconchs that probably indicate planktotrophic larvae, but that the protoconchs of the Ocenebrinae Cossmann, 1903, are paucispiral. *Ecphora* Conrad, 1843, the only fossil genus discussed by Kool (1993), was somewhat doubtfully placed in *Ocenebrinae* largely on the basis of its protoconch which has few whorls, is smooth, and has a smooth transition to teleoconch. Protoconchs of *Praesargana* appear to resemble those of *Sargana stantoni, Latiaxis serrata,* and some very short spired Pyropsidae. In *Praesargana* the protoconch is slightly less flattened than in *Sargana.* According to Garvie, 1991, unpublished work of Bandel on the protoconch of *Sargana* was the basis for removing sarganids from the Muricacea of the Neogastropoda and placing them in the Trichotropidae of the Neotaenioglossa.

One species of *Praesargana, P. condoni* (Weller, 1907), is known from the Turonian of northern California. The three new species from the Turonian of the Santa Ana Mountains, southern California, present a threefold increase in diversity in the more southern fauna, and *Praesargana* may represent a tropical stock. *Sargana is* found along the Gulf and Atlantic coasts but not in the Western Interior, a geographic range suggestive of warm rather than cool water. Its occurrence in South Africa *(Sargana geruasi* (Rennie, 1930) in a fauna that includes cypraeids also suggests warm water. That sarganids have not been found in the post Turonian of the Pacific Slope does not seem surprising as the Coniacian, Santonian, and Campanian appear to have been times of cooler climate here (Saul, 1986).

Sarganids are muriciform in shape and are similar to known predators, but do not resemble most herbivores, bottom browsers, filter, or ciliary feeders. A possible predatory habit does not certify that the sarganins are muricaceans, but it does militate somewhat against placing the sarganins among the ciliary feeding trichotropids and calyptraeaceans. Trichotropids of Turonian age were probably already cilliary feeding, protandric hermaphrodites. The probable warm water preference of sarganins also differs from that of trichotropids; their preference then as now seems to have been for cooler waters.

Despite similarities between Sarganinae and Muricinae of sculpture, aperture shape, anterior canal, and umbilicus, sarganins can be considered to be somewhat closer to pyropsins than to muricins. Protoconchs of pyropsins and sarganins are paucispiral, those of early muricids multispiral (Vokes, 1971). The posterior canal is most often similarly placed in pyropsins and sarganins. Both pyropsins and sarganins have a single fold on the columella at the anterior apertural constriction.

In the modern fauna, the genus most similar to *Pyropsis* is *Tudicla* — as in *Tudicla spirillus* Linnaeus, 1767, the sole Recent species and type of the genus *Tudicla.* In 1959 Abbott could find no anatomical data on this species, and Abbott (1994, pers. comm.), Ponder (June 1994, pers. comm.), and Warén (June 1994, pers. comm.) quizzed at the 1994 meeting of the Western Society of Malacologists knew of no anatomical descriptions. *Tudicla* resembles *Pyropsis* except for its protoconch, which in *Tudicla spirillus* is larger and more bulbus, and its outer lip which is internally lirate. The Mid Miocene species *Tudicla rusticula* (Basterot, 1825) from the Vienna Basin, Austria, is very similar to the type of *Tudicla* except that its protoconch is not so bulbous and high. The bulbous protoconch of *Tudicula spirillus* may be a derived characteristic convergent toward the protoconch of *Tudivasum* Rosenberg and Petit, 1987, of the Turbinellidae or Vasidae but not suggestive of relationship to the Turbinellidae. If the subfamilies Sarganinae, Pyropsinae, and Tudiclinae comprise the family Tudiclidae Cossmann, 1901, which is in the superfamily Muricacea, there are indeed muricacean gastropods from the Turonian of the Santa Ana Mountains, California.

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Author	**Order**	**Superfamily**	**Family**	**Subfamily**
Stephenson, 1923 & 1952	—	Rachiglossa	Sarganidae	—
Sohl, 1964	Neogastropoda	Muricacea	Muricidae	Rapaninae
Ponder & Warén, 1988	Neogastropoda	Muricacea	Muricidae	Sarganinae
Garvie, 1991	Neotaenioglossa	Calyptraeacea	Trichotropidae	—
Garvie, 1992	Neogastropoda	Cancellariacea	Cancellariidae	—
Tracy, et al., 1993	Neotaenioglossa	?	?	—
This paper	Neogastropoda	Muricoidea	Tudielidae	Sarganinae

Table 1. Systematic placement of *Sargana* by various authors.

TALE OF THE CARPENTER'S SQUARE

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The genus *Isognomon* [Lightfoot], 1786, is represented in the northeastern Pacific by the Panamic *I. janus* Carpenter, 1857, and *I. recognitus* (Mabille, 1895), both of which occasionally reach southern California in warm-water years. They are the only eastern Pacific species of this genus, records of a third in South American being in error. The type species of the genus has frequently been misquoted; it is *Ostrea isognomum* Linnaeus, 1758, by tautonomy, which was cited by [Lightfoot] as the later emendation *O. isognomon* Linnaeus, 1764.

WEST COAST CENOZOIC MARINE MOLLUSCAN PALEONTOLOGISTS: THE FIRST 100 YEARS

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The first studies of west coast molluscan fossils were undertaken by T. A. Conrad who studied material sent to him in Philadelphia by railroad exploration surveys. He was an easterner who never set foot on the west coast. His 1848 paper describing several species of Miocene mollusks from Astoria, Oregon,was the first publication dealing with west coast molluscan fossils.

The California legislature established a State Geological Survey in 1860, and its director, J. D. Whitney, hired W. M. Gabb, who studied molluscan fossils in Baja California, California, Oregon, Washington, and Vancouver Island, British Columbia. He once rode horseback 300 miles through hostile Indian lands from San Francisco to the Fort Tejon area, south of Bakersfield, to find reportedly Eocene fossils. His reports in 1864, 1868, and 1869 on Mesozoic and Tertiary fossils were the first publications issued by the California Geological Survey. He died at an early age from tuberculosis that was related to his contracting malaria while working in Costa Rica. James G. Cooper, who had been affiliated with this survey before it disbanded in 1874 for lack of funding, summarized in 1888 and 1894 the contributions of Gabb, as well as those of Conrad.

William H. Dall, the famous malacologist, also studied Cenozoic mollusks of the west coast for various U. S. Geological Survey mapping projects in Oregon and Washington. His 1909 monograph on Miocene faunas of Coos Bay and Astoria, Washington is a classic report.

The next phase of molluscan paleontological research on the west coast stemmed from J. P. Smith, the first paleontologist at Stanford, and from J. C. Merriam, the first paleontologist at University of California, Berkeley (UCB). Smith, who specialized in Mesozoic ammonoids, had much interest in Recent and Tertiary shells, and in 1919 he made one of the first interpretations of west coast Tertiary paleoclimates. He also hired Mrs. I. S. Oldroyd, whose extensive Recent shell collection had been purchased by Stanford at Smith's request, to curate the school's collections. Smith trained Ralph Arnold, who worked on mid-Tertiary and Quaternary fossils, especially pectinid bivalves. Arnold, in 1906, reported on the first biostratigraphic classification of the California Cenozoic. After a short but very important career in paleontology, he became very influential in the oil business, as well as in politics.

James P. Smith also trained C. A. Waring, who in 1917 attempted to clear up the rather confusing relations that had existed since Gabb's work on west coast Cretaceous and Eocene rocks and their molluscan faunas. In addition, J. P. Smith also trained Wayne Loel, who in 1932 with W. H. Corey, worked on the mollusks of the lower Miocene Vaqueros Formation in California.

Although vertebrate paleontology was J. C. Merriam's speciality, he trained many excellent students in invertebrate paleontology. One of his students was B. L. Clark, who became a teacher at UCB in 1911. He was very enthusiastic about his research on west coast Tertiary mollusks and their biostratigraphy. He attracted scores of graduate students and many of them did pioneering work on west coast Cenozoic mollusks. The UCB invertebrate paleontology collections increased dramatically in size due to Clark's own research and due to the research of his many students. Notable among these students are J. W. Durham, who has worked on Tertiary paleoclimates by utilizing mollusks and who is currently working on fossil echinoderms, and Harold Vokes, who has also worked on Eocene mollusks of California and who is currently working on middle Tertiary bivalves of the Caribbean region.

Another important student of J. C. Merriam was C. E. Weaver, who in 1942 completed the first biostratigraphic classification of the Pacific Northwest Cenozoic. He travelled almost exclusively on foot and spurned the automobile as too risky. Notable students of Weaver were Roy Dickerson, who worked on Paleocene mollusks in California and Oligocene mollusks in Washington; Katherine Van Winkle Palmer, who worked on Tertiary mollusks in Washington and the Gulf Coast; and E. L. Packard, who became a professor at the University of Oregon. Notable students of Packard were H. G. Schenck, who became a professor at Stanford University where he worked on fossil gastropods and other invertebrates from California; L. G. Hertlein, who worked on late Tertiary and Quaternary mollusks in California, and Ellen James Moore, who has worked on middle Tertiary mollusks of the Pacific Northwest and who is currently finishing the first compilation of descriptions and illustrations of Tertiary marine bivalves of California and Baja California.

Hubert G. Schenck influenced various molluscan paleontologists, including U. S. Grant IV and H. R. Gale, who in 1931 had their monograph published on Pliocene and Pleistocene mollusks of California.

A. Myra Keen, the famous west coast malacologist, maintained an active interest in Cenozoic mollusks of California. In 1940 she and H. G. Schenck prepared a handbook of illustrations of common fossils for the field geologist, and in 1944 she and H. Bentson prepared a very useful check list of California Tertiary marine mollusks.

Wendell P. Woodring devoted much of his research while working for the U. S. Geological Survey to middle Tertiary molluscan faunas of the Caribbean region, but in the 1930s and 1940s, he focused on the marine Tertiary molluscan faunas of southern and central California. Ralph B. Stewart, a U. S. Geological Survey paleontologist who worked with Woodring on some of these studies, restudied in 1926 and 1930 Gabb's California Cretaceous and Tertiary type bivalves and gastropods.

THE ATLANTID HETEROPOD'S "SPERMATOPHORE": IS IT OR IS IT NOT?

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Atlantid heteropods collected from Hawaiian waters occasionally have narrow elliptical, yellow capsules attached to their shells. Previous workers have also reported the presence of these structures on atlantid shells. In the late 1940's Tesch hypothesized that these capsules were spermatophores. Subsequent histological studies of the female reproductive system by Thiriot in the mid 1970's refuted the hypothesis of Tesch by showing that spermatophores are deposited directly in the female's mantle cavity. Recently I collected several atlantids in which the capsule contents were not yellow, but were brown and had distinctive structure. The capsules were found to contain pre-emergent nymphs of the ocean strider, *Halobates sericeus*. A total of 139 capsules, attached to 72 atlantids belonging to eight species, were collected during a series of cruises off Hawaii between 1984 and 1992. Most (86%) of the capsules were attached to only two species, *Atlanta turriculata* and *A. fusca*. The maximal number of egg capsules attached to a given shell was four, although most atlantids (79%) had one or two capsules. All atlantids with attached capsules were males, which is correlated with previous records of high densities of adult male atlantids in neuston samples. This appears to be the first record of *Halobates* attaching its egg capsules to a living substratum.

PREY SELECTION BETWEEN CO-OCCURRING SPECIES OF *TURRITELLA* BY DRILLING GASTROPODS IN THE GULF OF CALIFORNIA.

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Patterns of drilling predation on co-occurring species of *Turritella* by predators of the families Naticidae and Muricidae were compared between two sites on the mainland side of the Gulf of California. Prey shells differed in thickness at average drilling position and internal volume between species and sites. Shells of *T. gonostoma* were drilled more frequently by both predators at the Puerto Peñasco site, while *T. leucostoma* was drilled more frequently at Bahía Kino, although *T. leucostoma* was more abundant at each site. Both predator groups appeared to be selecting prey species in order to minimize cost-benefit ratios (shell thickness / (internal volume)(success rate)).

SHELL ULTRASTRUCTURES IN MAJOR GASTROPOD CLADES

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Shell ultrastructures —the three dimensional organization of lime and organic matter, observed in the cross section of a shell —may provide important data to unravel the phylogeny of gastropods: 1) The presence or absence of a certain structure may characterize a clade, 2) some clades have a characteristic sequence of structures, 3) shell structures comprise one of the only character complexes, which may be applied to fossil and recent material equally well. Patellogastropoda possess the apomorph regularly foliated and calciticcomarginal crossed lamellar structures, the family Lottidae has prismatic complex crossed lamellar structure. Vetigastropoda are characterized by intersected crossed platy structure, Haliotidae, Pleurotomariidae, Seguenziidae, Trochidae and Turbinidae are the only gastropods possessing columnar nacre, Trochidae and Turbinidae are additionally characterized by spherulitic prismatic structure. Outside Patellogastropoda and Vetigastropoda shell structures are less variable, crossed lamellar structures dominate. The sequence of structures may, however, be unique to a family or a larger clade. Neritimorpha are characterized by the sequence calcitic homogeneous, comarginal crossed lamellar, simple prismatic and a number of higher "prosobranchs" by the sequence comarginal crossed lamellar, radial crossed lamellar, comarginal crossed lamellar with minor modifications or additions. The structure cone complex crossed lamellar seems increasingly important, itself or structures derived from it are present in most gastropods. The growth of the rim of cones in certain directions gives rise to comarginal crossed lamellar and radial crossed lamellar structures and to certain complex crossed lamellar structures. The sequence comarginal crossed lamellar, radial crossed lamellar, comarginal crossed lamellar in higher"prosobranchs" originates from cone complex crossed lamellar structure,where the rim of cones has grown selectively in directions at right angles to each other. Shell ultrastructures may be observed in shells of recent as well as fossil gastropods. Unaltered fossil shells are abundant in the Tertiary, but occur even in the Palaeozoic. Apart from shell morphology, shell ultrastructures comprise the only character complex, which may be applied to recent and fossil species, supporting a common phylogeny

ENVIRONMENTAL SCANNING ELECTRON MICROSCOPY (ESEM) APPLIED TO MOLLUSKS

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ESEM is an extension of traditional Scanning Electron Microscopy (SEM),with less strict requirements to specimen preparation. It is possible to study samples, which are wet, greasy and without a conductive coating. Consequently, it is possible to study tissue and radulae, which have not been distorted or in other ways changed by drying or fixation, and to examine type material without inducing any changes in chemistry or physical appearance. Techniques requiring less specimen preparation are less likely to produce artifacts and thus to a higher degree reflect the true nature of the study material. The ESEM at Museum of Paleontology (Berkeley) is now used on a routine basis to study material, which otherwise would not be available due to rarity of specimens or difficulty with preparation

EFFECTS OF ORGANIC ENRICHMENT ON MOLLUSCAN DISTRIBUTION AND ABUNDANCE ON THE MAINLAND SHELF OFF OF SAN DIEGO

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Three out of five common species of marine infaunal mollusks are found to respond to a source of organic enrichment near the city of San Diego's deep ocean outfall. Treated sewage effluent, which is primarily organic in composition due to low industrial input, is discharged into coastal waters at a depth of 60 m. The city of San Diego monitors multiple effects of the discharge, including patterns in abundance and distribution of fish and macro-invertebrate populations.

By way of example, eight stations along the 60-m depth contour and spanning the terminus of the outfall were examined for patterns in the distribution and abundance of infaunal mollusks. These stations range from 0.5 kilometers to 17 kilometers away from the discharge. Of the five most abundant mollusks, *Tellina* sp. A, *Nuculana taphira*, and *Parvilucina tenuisculpta*, showed a significant increase in abundance with proximity to the outfall. The other two species, *Volvullela panamica* and *Cylichna diegensis* did not display an apparent trend.

PHYLOGENY OF THE COLUMBELLIDAE (GASTROPODA: NEOGASTROPODA): PROGRESS TOWARD A NEW SYNTHESIS

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The family Columbellidae comprises a group of several hundred small marine snails, which like other groups, has traditionally been diagnosed and classified solely on the basis of shell and radular morphology. Research over the last thirty years, however, has shown wide anatomical variation within the family, particularly in the reproductive system. This information, combined with the long recognized variability of columbellid shell form and lifestyle, has reinforced the need for a phylogenetic re-evaluation of the family.

The cladistic phylogeny presented here is not a final result, but a progress report of a project currently underway, to understand the evolutionary history of a portion of the Columbellidae, centering around the genus *Columbella*. This particular group, though not particularly diverse, is noteworthy for several reasons; its members are apparently facultative herbivores, and may have either planktotrophic or crawl-away larvae. Their evolution is staged around the closure of the Panamanian Isthmus, and the genus itself has a reasonable chance of being a monophyletic group. This preliminary phylogeny includes data from shell and opercular morphology, radular form, alimentary and reproductive anatomy, and reflects trends primarily in reproductive anatomy and radular morphology, discussed here. It supports the monophyly of Columbellidae and of the genus *Columbella* within it, and species from other nominal genera have been included to evaluate generic relationships within the family and the potential monophyly of those genera. The completion of this project will provide a new synthesis of columbellid evolution, illustrating evolutionary trends in shell form, reproductive and feeding strategies, and will be valuable as a model system for comparison with other neogastropod taxa, many of which share similar characteristics and ecological niches.

A POSSIBLE CAUSE FOR CYPRAEID MELANISM IN NEW CALEDONIA

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Unusual rostrate and melanistic cowries from New Caledonia have been recognized since the mid 1800's. These strange, irregular forms have attracted the attention of numerous conchologists, both professional and amateur. A close examination of this phenomenon reveals that the irregular growth and pigmentation patterns are not expressed during the juvenile marginal progradation, but only during adult surficial aggradation. Thus,the irregularities must be unique to this different biomineralization mode. Also, because many species independently express this phenotype, it is assumed to be caused by an external factor unique to that locale.

The rostration and melanistic phenomena are restricted to the southwestern coast of New Caledonia. Comparison of the distribution of geologic formations reveals that there is a remarkable concordance between the presence of an eluvial ferrigenous deposit and the occurrence of melanism. This geologic formation is a weathered incoherent ore deposit rich in nickel, iron, cobalt, chromium, and copper. Certain spin-stabilizing metal ions including copper, cobalt, nickel, zinc and iron are known to be involved in the formation of melanin pigments. These metal ions act as catalysts and affect the kinetics of biochemical reactions in the metabolic pathway for the synthesis of melanins. Furthermore, it has been shown that added amounts of copper not only increase the activity of the tyrosinase enzyme, but also increase the amount of enzyme transcription. The correlation of this metal rich substrate with the irregular cypraeid forms and the role that metal ions play in the melanin biochemical pathway strongly suggest a causal link between the two and certainly warrants further investigation.

INVERTEBRATES ASSOCIATED WITH LAND SHELLS

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Abstract

Information about the deployment of shells (live or dead) by marine invertebrates is profuse. By contrast, the records for terrestrial and freshwater shells are scarce. A library search showed that the information is dispersed in dissimilar journals and books. For land shells there are some records about the employment of them by invertebrates; for example: mosquitoes breed their eggs on snail shells, while solitary bees make their nests in them. Spiders and the beetle *Carabus* also find shells a suitable shelter. Five different groups of arthropods (Class Diplopoda; Class Arachnida, Orders: Scorpionida, Araneida; and Class Insecta, Orders: Diptera, and Coleoptera) were found occupying land shells. The percentage of animal occupancy of shells is very low (only 16 records for 10 years of data collection).

Introduction

There is a great amount of information on marine invertebrates and algae that utilize mollusk shells as a substrate or a movable burrow (Hazlett, 1981); however, less work has been published on land and freshwater invertebrates. During the course of this study, literature on the use of shells of terrestrial and freshwater invertebrates was reviewed. It was quickly discovered that there were few publications on the topic and that they were in widely scattered journals.

Some land invertebrates have been observed associated with empty shells. This pseudo-carapace provides protection, as well as a nesting or a breeding place for pseudoscorpions, spiders, bees and flies. Spiders utilize molluscan shells as refugia, for example the spider of the genus *Phonognatha* (Ana Hoffman, pers. comm.). Recently *Phonognatha graeffi* from Victoria, Australia, was observed to utilize a shell of *Helix aspersa* as shelter (Hewish & Hewish, 1990).

Pseudoscorpions may use shells as shelter during molting and protection from extreme weather (Taylor et al., 1977).

Two genera of terrestrial hermit crabs, *Coenobita* and *Birgus*, (Anomura) use empty shells (Powers & Bliss, 1983). The importance of the shell for these crabs in the adaptations to life on land is significant. The shell can supply safety, assist in conservation of water, provide insulation from excessive heat gain or loss (McMahon & Burggren, 1979), and act as a refugium to protect eggs (Hazlett, 1981).

As shells are natural cavities some mosquitoes (Diptera) make use of them for breeding. A variety of genera have been reported to lay eggs in gastropod shells. In Dar es Salaam (Tanzania) *Aedes aegypti* lays its eggs in land shells. In addition, the mosquitoes *Culex fatigans* and *C. nebulosus* were found in land shells with *Aedes* (Ramachandra et al., 1973). Trpis (1973), at the same locality, observed that *Aedes aegypti, A. simpsoni* and *Eretmapodites quinquevittatus* occupied 11 to 35 % of *Achatina fulica* shells.

The beetle, *Carabus* (Coleoptera), also uses empty shells to dwell (Sigida, 1987). Some members of the family Lampyridae (Coleoptera) feed on land mollusks.

Several genera of bees nest in terrestrial shells (Belloveye, 1870), including *Osmia*, *Ashmeadiella*, *Hoplitis*, and some species of *Rhodanthidium*. In Eurasia this is commonly reported, whereas in America only *Ashmeadiella* has been found nesting in gastropod shells. Bees divide the shell into cells with leaf mastic, sheep or rabbit dung, saliva, resin and snail shell fragments (O'Toole & Raw, 1991). A large shell (*Helix pomatia*) might be divided in 10 cells, although small shells (*Cepaea nemoralis* and *C. hortensis*) will house one cell only (Belloveye, 1870; Westrich, 1990; O'Toole & Raw, 1991).

Flies of several families are parasitoids (*Megaselia fuscinervis* - Disney, 1982; and Sciomyzidae flies), predators, or scavangers (Sarcophagidae) of land and freshwater mollusks (Disney, 1973a, 1973b, 1977, 1982; Vala & Gasc, 1990). Disney (1977) reported two cases of slug egg predation by *Megaselia ciliata* and *M. aequalis*. Several parasitic flies lay their eggs near or on live or dead mollusks. The larvae need the mollusks to complete their development. Some larvae leave the shell prior to pupation (*Paraspiniphora maculata*; Disney, 1973a), others pupate in the snail (*Hydrotaea occulta* and *Hylemya strenua*; Disney, 1973a). *Pherbellia* and *Colobaea* close the shells of their hosts with a calcareous plate to terminate their pupation phase (Chandler et al., 1978).

Results

Over the past 10 years, I have inadvertently discovered shells occupied by invertebrates while collecting terrestrial mollusks. This resulted in a small number of new records presented here. Of the shells collected that were occupied by invertebrates, five orders of arthropods were represented including pseudoscorpions, spiders, spider webs, Diplopoda larvae (dead), Diptera molts, Lampyridae and *Plagiodera* sp. (Coleoptera) (Table 1).

Pseudoscorpions were inside *Sonorella* sp. Spider webs were found in *Sonorella* sp., *Orthalicus* sp., *Drymaeus* sp. and *Rabdotus* sp. Live Diptera larvae have been encountered twice, one of them on the genus *Drymaeus* and the other on *Pomacea*. The larva found inside one specimen of *Orthalicus* sp. was raised to adulthood (Sarcophagidae). Diptera molts were found in *Succinea undulata*, *Helminthoglypta fieldi*, *Rabdotus* sp. and *Sonorella* sp. A millipede was collected in a *Streptostyla* sp. shell. A Lampyridae was found in an apparently dormant *Drymaeus* sp. attached to a Convolvulaceae-like vine; however, the shell was empty. A member of the genus *Humboldtiana* was observed with a dormant beetle of the genus *Plagiodera* sp. (Chrysomelidae). The beetle was found in the umbilicus of a live snail estivating in a rock depression. Finally, I observed a hermit crab using the terrestrial shell, *Orthalicus* sp. All other hermit crabs at the site bore marine shells.

Discussion

The percentage of occuppied shells found during this study was low, yielding only 16 records. Possibly this is due to the invertebrates crawling out of the shell after it is collected. The use of terrestrial and freshwater shells by other animals has not been fully explored when compared to the diverse literature on marine shells. More data about these occurences may help us understand the ecological relationships between mollusks and their shells, and other terrestrial invertebrates.

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Genus	Diplopoda	Pseudoscorpion	Araneidae	Spider web	Sarcophagidae	Diptera larvae	Diptera molts	Coleoptera	Lampyridae
Pomacea	-	-	-	-	-	+	-	-	-
Succinea	-	-	-	-	-	-	+	-	-
Drymaeus	-	-	-	+	-	+	-	-	+
Orthalicus	-	-	+	+	+	-	-	-	-
Rabdotus	-	-	-	+	-	-	+	-	-
Streptostyla	+	-	-	-	-	-	-	-	-
Humboldtiana	-	-	-	-	-	-	-	+	-
Helminthoglypta	-	-	-	-	-	-	+	-	-
Sonorella	-	+	+	+	-	-	+	-	-

Table 1. Genera of molluscan shells inhabited by land invertebrates

PARASITES AS AN AID TO RESEARCH ON SHORT-FINNED SQUID BIOLOGY AND FISHERIES IN SPAIN

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Spain is the second largest squid consuming country in the world, with an estimated annual consumption of 75,000 mt in the 1980's and an annual per capita consumption of about 4 kg. Spain has by far the largest harvest of squids in Europe, and occasionally exports surplus to her European neighbors. The Spanish market targets two major genera: *Loligo* and *Illex*. The main Spanish market for the Ommastrephid *I.coindetii* and a second sympatric short-finned squid, *T. eblanae*, is supplied from several far-seas areas such as USA (Boston), Argentina, Canada, New Zealand, Namibia, Norway and Asian countries. However, Spain has lost most of their traditional far-seas fishing grounds because of worldwide national jurisdiction laws over coastal fishing areas. This has given rise to an intense interest in a virtually unexploited domestic resource. At present, local catches of these two squids are relatively minor compared with other fisheries which traditionally target more economically important species such as hake, blue whiting and lobster. Contributing to the current absence of squid fisheries off Galicia is the almost total absence of information on squid biology, fishing methods and management practices.

In 1991 a multi-disciplinary project was initiated to study squid biology and fisheries in order to obtain more data on the local fishery potential. This project is interesting because it is using a variety of techniques to aid in resolving problems relating to squid fisheries off Galicia. The use of parasites has been well documented in elucidating the biology of fish species. My study involves an eco-parasitological analysis of squid stocks on the fishing grounds off Galicia (NW Spain). This project includes: 1) identification of metazoan parasites (helminths and copepods); 2) population dynamics and community structure (recruitment and development of models); 3) host-parasite interactions (trophic and biotic relationships,associated pathology); 4) ecology of parasites (parasite transmission related to biotic and abiotic factors); and 5) application of this knowledge to the identification and discrimination of squid movements, trophic ecology and stock composition in the waters off the Iberian Peninsula.

PEARLS '94: THE FIRST INTERNATIONAL PEARL CONFERENCE

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A report on the first international conference held strictly for the pearling world. This conference was held in Honolulu during 15-19 May 1994. It was sponsored by the International Pearl Association and hosted by the State of Hawaii Agriculture Development Program of the Department of Land and Natural Resources as well as several other agencies.

There were nine plenary speakers, 51 technical papers, 24 exhibits and posters, as well as a jewelers' forum and a sales area for wholesale buyers. Speakers represented work being done in Australia, China, Cook Islands, France, India, Iran, Japan, Kuwait, Mexico, New Caledonia, Philippines, Solomon Islands, Tahiti and the USA. Topics included land based freshwater and marine hatcheries, pearl manufacture, spat growing techniques and the production of pearls from various taxa. Exhibits illustrated the biology of the nacreous mollusks and their historical and commercial uses.

The exhibits were made possible by loans from U.S. museums, state and federal agencies, shell club members and pearl and shell product dealers.

COLLECTING LANDSNAILS IN THE BAHAMAS, 1994

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The genus *Euglandina* is not included in Deisler & Abbott's 1984 list of the landsnails introduced to the Bahamas. A search of the post-1984 literature for species of *Euglandina* in the Bahamas has not been successful.

In March 1994, specimens of a species of *Euglandina* were collected on two of the islands: New Providence (at Foxhill and Millars) and Grand Bahama (at Freeport, Rand Nature Center, and West End). *Euglandina* cf. *rosea* (Ferussac, 1821) appears to be a post-1984 introduction to the Bahama landsnail fauna.

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CHROMOSOMES OF THE FRESHWATER CLAM *ANODONTA CHAPALENSIS* CROSSE AND FISHER, 1892, FROM MICHOACAN, MEXICO

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Among molluscs, the majority of cytogenetic studies have been conducted on the gastropods. Far less is known about the bivalves. Freshwater bivalves of the family Unionidae encompass 225 species and subspecies within 45 genera in North America.

Mitotic chromosomes in metaphase (Figure 1) were obtained from the branchial tissues of *Anodonta chapalensis* according to the techniques proposed by Kligerman & Bloom, 1977; Ieyama, 1982; Jenkinson, 1976; and Dagostino, 1986. Specific modifications included a preliminary treatment with calcium chloride, which stimulated cell division but avoided the concentration and contraction that chromosomes suffer because of colchicine (Subrahamanyam, 1969).

Our study is based on 15 chromosome fields, obtained from 20 organisms that we sampled.

The karytoype presents a diploid number 2n = 38 chromosomes. A statistical analysis (Table 1) based on the measurements of the short arms (P) and the long arms (Q), helped us to organize the homologous pairs and to characterize their morphology. Hence we are able to present an illustration of the characteristic ideogram of the chromosomes of *Anodonta chapalensis* (Figure 2).

The modal diploid number is 2n = 38, with a chromosomal formula of FC = 5M + 14Sm (that is, 5 central pairs, and 14 subcentral pairs). The fundamental number is NF = 76.

We did not see the presence of heteromorphic chromosomes, which would indicate a sex chromosome, within the population studied.

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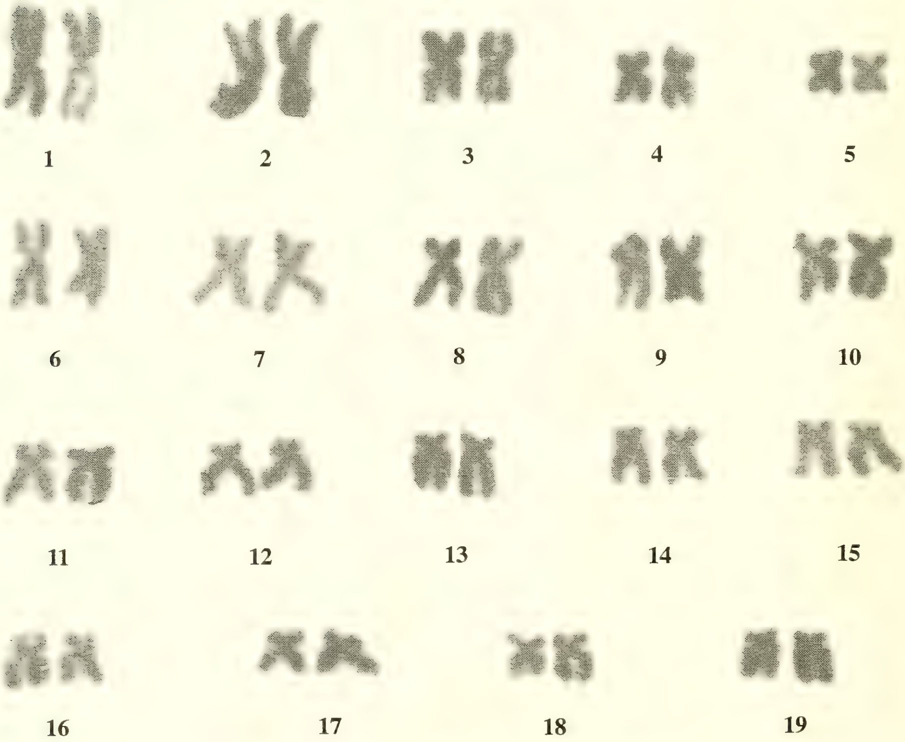


Figure 1. Cariotype of *Anodonta chalapensis*, from Celio River, Jacona, Michoacan, Mexico (2n=38).

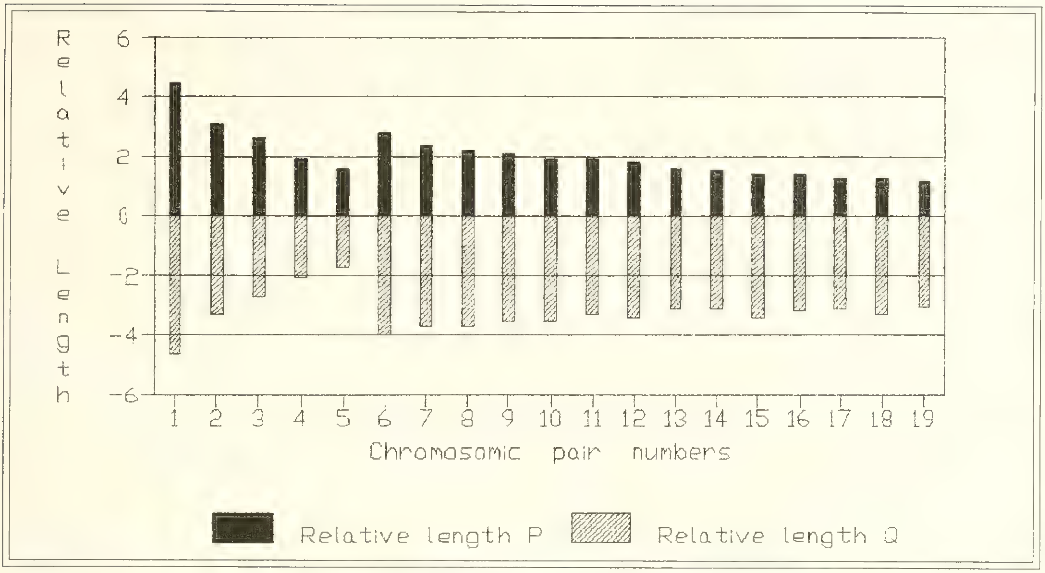


Figure 2. Ideogram of *Adodonta chapalensis* (Jacona, Michoacan, Mexico)

Chromosomic Number	Relative Length p	Relative Length q	Relative Length p+q	Centromeric Index	Arm Proportion p&q	Arm Differentiation	Classification
1	4.47	4.61	9.08	49.23	1.03	0.15	Mediocentric
2	3.06	3.26	6.32	48.42	1.07	0.32	Mediocentric
3	2.49	2.69	5.18	48.07	1.08	0.39	Mediocentric
4	1.89	2.07	3.96	47.73	1.10	0.45	Mediocentric
5	1.64	1.71	3.35	48.96	0.45	0.21	Mediocentric
6	2.81	4.01	6.82	41.20	1.43	1.76	Submediocentric
7	2.38	3.66	6.04	39.40	1.54	2.12	Submediocentric
8	2.16	3.63	5.79	37.31	1.68	2.54	Submediocentric
9	2.05	3.52	5.57	36.80	1.72	2.64	Submediocentric
10	1.93	3.49	5.42	35.61	1.81	2.88	Submediocentric
11	1.89	3.28	5.17	36.56	1.74	2.69	Submediocentric
12	1.83	3.37	5.20	35.19	1.84	2.96	Submediocentric
13	1.76	3.12	4.88	36.07	1.77	2.79	Submediocentric
14	1.66	3.08	4.74	35.02	1.86	3.01	Submediocentric
15	1.55	3.36	4.91	31.57	2.17	3.69	Submediocentric
16	1.52	3.14	4.66	32.62	2.07	3.48	Submediocentric
17	1.42	3.07	4.49	31.63	2.16	3.67	Submediocentric
18	1.35	3.26	4.61	29.28	2.41	4.14	Submediocentric
19	1.19	3.20	4.39	27.11	2.69	4.58	Submediocentric

Table 1. Classification parameters of the chromosomes from *Anodonta chapalensis.*

ON THE IMPORTANCE OF *ANTIPLANES VOYI* FOUND LIVING IN SPONGES

Walter D. Schroeder
8101 La Palma Circle, Huntigton Beach, California 92646-1655 USA

During the 1950's shrimp boats collected hundreds of leuconoid sponges off the coast of San Luis Obispo County, California. In many cases these sponges contained the sinistral turrid *Antiplanes voyi* (Gabb, 1866).

Five hundred turrid specimens were collected in sponges by Lawrence Thomas at the 84 fathom curve off Pt. Bushon. Of the specimens collected 499 were *Antiplanes voyi* and one was *Antiplanes thalaea*. Included in the collection were two new size records, namley 70.3 mm for *A. voyi* and 46.6 mm for *A. thalaea*.

A theory of sinistral evolution postulated for Triphora by Bertram Draper may be applicable to the occurrence of *A. voyi* in sponges. However more detailed study is needed of the relationship between these mollusk groups and sponges.

Minutes
Executive Board Meeting
Western Society of Malacologists
Santa Barbara, California
27 June 1994

President Kirstie Kaiser called the meeting to order at 4:17 p.m.

Present: Kirstie Kaiser, Henry Chaney, Dave Mulliner, George Metz, Kit Stewart, Nora Foster, Marge Bradner, Hugh Bradner, Ken Lindahl, Terry Arnold, Paul Scott.

Secretary's Report: Terry Arnold read the Minutes of 1993 Board of Directors and business meetings. The board accepted minutes as read.

Treasurer's Report: Henry Chaney reported that the society had 132 regular members and 104 members were paid in full as of today.

The savings account balance was currently at $11,072, the checking account balance was approximately $5,000, and the donations to the symposium fund in the last year was $325.

Student Grants: Chairman Paul Scott announced that 29 proposals were received for this year's student grant. The student grant committee (P. Scott, H. Chaney, J. Nybakken, L. Groves, W. Miller, E. Coan) will meet in the next few days to decide on the winners of the grant. The available pool of funds for this years grant is $1875 ($1,000 from WSM, $500 from the Santa Barbara Malacological Society, $250 from the San Diego Shell Club, and $125 from the Northern California Malacozoological Society.

Nominating Committee: The following slate of officers for 1995 was proposed by Nominating Committee chairman David Mulliner.

President	Nora Foster
First Vice President	Hugh Bradner
Second Vice President	Sandra Millen
Treasurer	George Metz
Secretary	Terry Arnold
Members at large	Kenneth Lindahl Roland Anderson

Assurances were provided by Dave Mulliner that all persons nominated were willing to serve. The issue was raised whether the bylaws permitted a past president to serve as a member at large. It was determined that this was permitted by the bylaws. The slate was accepted as proposed and will be submitted for a vote at the general membership business meeting.

New Business: President-elect Nora Foster reported that the 1995 Annual Meeting of the WSM will be held at Chena Hot Springs, which is 2 hours NW of Fairbanks, Alaska. The tentative dates are June 2-5 1995. Anticipated cost $85/person/day for meals,lodging and meeting rooms. Transportation from Fairbanks will be arranged by Foster. Possible symposia for the meeting include: Arctic Ecology, Beringia, Paleoecology

Second Vice-President Hugh Bradner announced the 1996 Annual Meeting will be held in San Diego, California, with a tentative date of the week before 4th of July weekend. Symposia are yet to be decided.

Honorary Life Membership for Bill Emerson was proposed. This proposal was passed by acclimation. This will be announced at the banquet rather than at the business meeting.

There being no further business, the meeting was adjourned at 5:10 p.m. by President Kaiser.

Respectively submitted by Terry S. Arnold, Secretary

Minutes
Annual Business Meeting
Western Society of Malacologists
Santa Barbara, California
29 June 1994

President Kirstie Kaiser called the meeting to order at 3:45 p.m.

Treasurer's Report: Henry Chaney reported that the society had 132 regular members and 30 institutional members. Current accounts include: Savings (CDs $8000 & 2000, Passbook $1072); Premeeting cash position $15000 (approx); Reprint sales $ 200; Auction proceeds $2635.

Motion to accept treasurer's report made, seconded and passed.

Best Student Paper: Jim Nybakken announced that a two year membership will be given to Marta de Maintenon for the best student paper/poster award for the 1994 meeting.

Student Grants: Chairman Paul Scott announced that 29 proposals were received for this year's student grant. The student grant committee (P. Scott, H. Chaney, J. Nybakken, L. Groves, W. Miller, E. Coan) will meet in the next few days to decide on the winners of the grant. The available pool of funds for this years grant is $1875 ($1,000 from WSM, $500 from the Santa Barbara Malacological Society, $250 from the San Diego Shell Club, and $125 from the Northern California Malacozoological Society.

Applicant Statistics: 14 Female, 15 Male; Proposal Statistics: 21 Marine, 4 Freshwater, 1 Terrestrial, 4 Paleontology.

Grant Awards Proposed:

$825	Timothy A. Rollins, University of Alberta
$500	Tamara Ross, Iowa State University
$500	Mario Tamburi, University of South Carolina

Motion to approve proposed grants made, seconded and passed. A proposal was made to make the following additional undergraduate special grants. Motion to approve proposal made, seconded and passed.

$200	Amy Jo Davis, Gonzaga University
$200	Jody Went, Rider University

Proposal was made to continue WSM funding of student grants at $1000 level. Motion to approve proposal made, seconded and passed.

Nominating Committee: The following slate of officers for 1995 was proposed.

President	Nora Foster
First Vice President	Hugh Bradner
Second Vice President	Sandra Millen
Treasurer	George Metz
Secretary	Terry Arnold
Members at large	Kenneth Lindahl Roland Anderson

Nominations from the floor were solicited. None were proposed. Motion to accept the slate of officers as proposed was made, seconded and passed.

Annual Report: Paul Scott indicated that the 1993 Report delivered late due to change in publication method. Cost is now $550 rather than $2200 for previous years. Change in cost is due to use of desktop publishing and scanning permitting less expensive printing for equivalent quality.

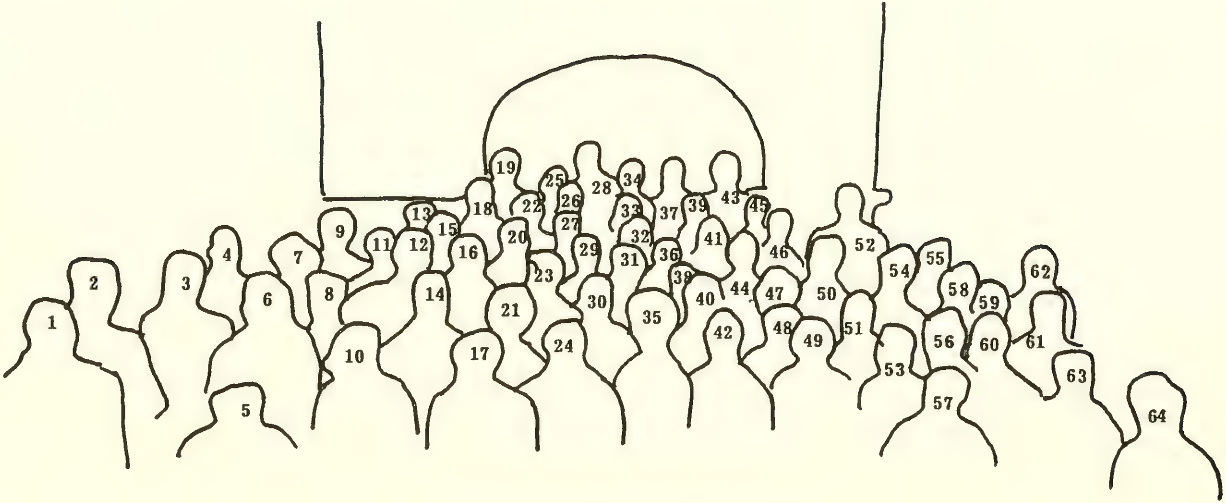
1995 WSM Meeting: President-elect Nora Foster reported that the 1995 Annual Meeting of the WSM will be held at Chena Hot Springs, which is 2 hours NW of Fairbanks, Alaska. The tentative dates are June 2-5 1995. Anticipated cost $85/person/day for meals,lodging and meeting rooms. Transportation from Fairbanks will be arranged by Foster. Possible symposia for the meeting include: Arctic Ecology, Beringia, Paleoecology. B&Bs in Fairbanks area will be recommended for attendees coming early or staying later. The GSA meeting will precede the WSM meeting.

1996 WSM Meeting: Second Vice-President Hugh Bradner announced the 1996 Annual Meeting will be held in San Diego, California, with a tentative date of the week before 4th of July weekend. Symposia are yet to be decided.

New Business: It was announced that the 1995 AMU meeting will be in Hilo Hawaii 7-13 June. There will be Symposia on Island Biogeography and Cephalopods.

There being no further business, the meeting was adjourned at 4:40 p.m. by President Kaiser.

Respectively submitted by Terry S. Arnold, Secretary



1994 Annual Meeting Group Photograph
Santa Barbara Museum of Natural History
29 June 1994

1. Joseph Johnston
2. Kirstie Kaiser
3. Henry Chaney
4. Walter Sage
5. Beatrice Burch
6. Thomas Burch
7. Wendy Koch
8. Tucker Abbott
9. Eric Hochberg
10. Edna Naranjo-Garcia
11. Gale Sphon
12. Paul Skoglund
13. Anders Warén
14. Ken Lindahl
15. Carole Hertz
16. Roma Metz
17. Maria Diupotex
18. Kent Trego
19. Lindsey Groves
20. George Metz
21. Marge Lindahl
22. Jules Hertz
23. Carol Skoglund
24. Jean Cate
25. Winston Ponder
26. Ross Nehm
27. William Emerson
28. Robert Koch
29. David Mulliner
30. Neil Fahy
31. Walter Schroeder
32. Barbara Chaney
33. Claus Hedegaard
34. Donald Shasky
35. Lois Pitt
36. Megan Lilly
37. Richard Saul
38. Marta de Maintenon
39. Christopher Meyer
40. William Pitt
41. Paul Scott
42. Alison Kay
43. Terry Arnold
44. Sandra Millen
45. Eugene Coan
46. Nora Foster
47. Minnie Ball
48. LouElla Saul
49. Bunnie Cook
50. Lance Gilbertson
51. George Kennedy
52. George Cook
53. Twila Bratcher Critchlow
54. Douglas Eernisse
55. Terry Gosliner
56. Debra Tull
57. Rosemary Adams
58. James McLean
59. Robert Cowie
60. Thomas Critchlow
61. Ellen Jackson
62. John Jackson
63. Margaret Mulliner
64. Kit Stewart

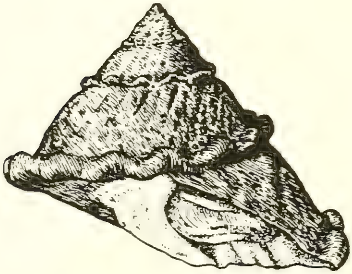
WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1993 - 30 September 1994

INCOME

Membership dues	$2302.00	
Student grant donations (1993)	358.00	
Symposium fund	313.00	
Interest on savings accounts	379.09	
Auction and reprint sales	2140.00	
1994 conference	6263.00	
TOTAL INCOME during period		**$11,755.09**

EXPENSES

Annual report	$660.27	
Memberships and fees	47.00	
Reimbursements to officers	241.39	
1994 Student grant (including carryover from 1993)	1400.00	
1994 Symposium expenses	1043.20	
1994 Conference	8159.11	
TOTAL EXPENSES during period		**$11,550.97**
Net gain for period		204.12
Beginning balance (1 October 1993)		13,842.63
NET WORTH on 1 October 1994		**$14,046.75**



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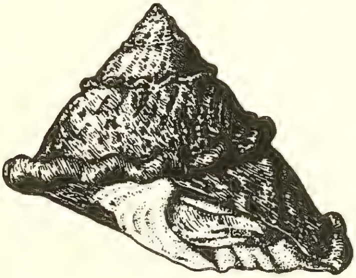

JUNE 1995 MEETING

The Western Society of Malacologists

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The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the Annual Report is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $15.00 for regular members, $17.00 family, and $6.00 student.

The Western Society of Malacologists has issued three **Occasional Papers** - No. 1, "'Sea Shells of Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan; and No. 3, "Twenty-five Year Index to Publications of the Western Society of Malacologists: Author, Taxonomic, Geographic and Subject Indices," by Hans Bertsch.

Correspondence regarding membership and orders for additional or back issues of the **Annual Report** or the **Occasional Papers** should be addressed to the current W.S.M. Treasurer, Dr. George Metz, 121 Wild Horse Valley Drive, Novato, CA 94947 USA.

In Memoriam

R. Tucker Abbott (28 September 1919 - 3 November 1995) Sanibel Is., Florida

Gale G. Sphon Jr. (4 June 1934 - 12 May 1995) Lake Isabella, California

Harold W. Harry (17 February 1921 - 30 June 1995) Bellaire, Texas

INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be in the form of: Abstract, Extended Abstract, or Full-length Paper. Each is reviewed by the Editorial Board; outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8 1/2" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The works in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Chair, Department of Mathematics & Natural Sciences, National University, 4125 Camino del Rio South, San Diego, CA 92018 USA.

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REPRODUCTION OF *MYTILUS TROSSULUS* IN PORT VALDEZ, ALASKA

Arny Blanchard
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Fairbanks, Alaska 99775

The reproductive biology of *Mytilus trossulus* was investigated as part of environmental monitoring programs in Port Valdez, Alaska. *Mytilus trossulus* in Port Valdez demonstrate a year-long reproductive cycle with gametogenesis occurring from late fall to early spring and spawning from spring throughout the summer. Nutritive cell decreases are strongly correlated with increases in gametogenic tissues.

RESTORING MUSSEL BEDS FIVE YEARS AFTER THE EXXON VALDEZ OIL SPILL

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The persistence of *Exxon Valdez* crude oil underlying some dense mussel (*Mytilus trossulus*) beds in Prince William Sound (PWS) and the Kenai and Alaska Peninsulas began to cause concern in the spring of 1991. These beds were intentionally left untreated during cleanup activities, 1989-1991, because they provided physical stabilization in the intertidal area and the mussels were a food source for higher consumers. The beds did not appear to be recovering rapidly through natural processes and the continued presence of oil-contaminated mussels could be incorporated into the food chain and affect consumer species. As the residents of PWS became aware of the extent and persistence of oiling underneath the mussel beds, they also advocated restoring beds that could be treated manually.

In 1992 and 1993, the Auke Bay Laboratory documented 31 mussel beds in PWS with underlying sediment concentrations in excess of 10,000 fg/g total petroleum hydrocarbons (TPH). Mussels from these beds contained the highest petroleum hydrocarbons seen in PWS since 1990. ABL also conducted minimally intrusive tests (stripping and patch removal) to ascertain if these simple methods facilitated flushing of underlying oil with reduction in body burdens of petroleum hydrocarbons in mussels. These methods were unsuccessful.

In 1994, cooperatively with the Alaska Department of Environmental Conservation and funded by the Exxon Valdez Trustee Council, sites for restoration were selected based on 1) high concentrations of oil in mussels and underlying sediments in dense mussel beds, 2) underlying sediments suitable for manual handling, 3) adjacent source of suitable replacement sediments, and 4) area suitable for dispersal of oiled sediments removed from the bed.

Twelve mussel beds at five different locations were restored during the field season, 1994. The beds ranged in size from 9 to 35 square meters. During a low tide, mussels were removed and transferred to absorbent pads, flushed with water and allowed to further rinse on the pads through one tidal cycle. Oiled sediment was removed to depths from 8 to 12 cm, transported to a dispersal site and also placed on absorbent pads. Following one tidal cycle, clean sediment was transported and placed in the prepared bed; then the mussels were replaced. The dispersed sediments were removed from the pads and raked for maximum surface area exposure to air and water. Samples of mussels and sediments for hydrocarbon analyses were collected 2 months before restoration, throughout the restoration process, and 10-25 days following restoration. A total of 18.9 cubic meters of sediment weighing an estimated 38 tons was removed and dispersed. Preliminary evaluation 10 and 25 days after restoration indicates a 93- 97% reduction in sediment TPH immediately underlying the mussels and an 85-98% reduction of TPH in the dispersed, excavated sediments. All beds appeared stable with the restored mussels reattaching themselves to the replacement sediments.

Short-term evaluation of the mussel bed restoration process indicates successful removal of Exxon Valdez oil from close contact with overlying mussels; however, long-term assessment awaits further sampling and evaluation during the field season in 1995.

SOME ASPECTS OF THE BIOLOGY OF LIMPETS IN PORT VALDEZ, ALASKA, WITH EMPHASIS ON *TECTURA PERSONA*

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Port Valdez, a 10-mile long fjord, is the terminus of the oil pipeline originating in Prudhoe Bay and the location of a major Marine Terminal that serves as a trans-shipment site for oil to docked tankers. Most of the shore comprises a rocky substrate with a relatively dense, but species poor, intertidal flora and fauna. The fauna is dominated by barnacles and mussels, but six species of limpets are interspersed throughout much of the intertidal region: *Tectura persona*, *T. fenestrata*, *T. scutum*, *Lottia pelta*, *L. borealis* and *Acmaea mitra*. The temporal variability of adults and juveniles appears related to changing physical conditions within the marine environment of the Port. Compared to California *T. persona*, the limpet in Port Valdez is smaller and lives longer. The period with the greatest spawning intensity of *T. persona* occurs from October through December when surface-water temperatures begin a rapid decrease from the summer high values. The reproductive cycle of *T. fenestrata* overlaps that of *T. persona*, but it initiates spawning earlier than *T. persona*. Winter spawning by both species, when food availability is minimal, suggests that larvae released are demersal. Juvenile limpets are first apparent in spring and early summer at lower tidal levels when they graze on filamentous algae covering rocky surfaces at this time. The relationship of limpets in Port Valdez to the Marine Terminal are discussed.

NORTHEASTERN PACIFIC GASTROPOD FAUNA: PROGRESS TOWARD THE COMPLETION OF A CHECKLIST AND ILLUSTRATED BOOK

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Over the last 30 years I have attempted to keep track of the approximately 1,200 gastropod species of the northeastern Pacific, from the Bering Sea and Alaska, ranging south to the outer coast of Baja Californina, Mexico. Copies of original and subsequent descriptions and photos of types and other specimens have been maintained in a series of loose-leaf notebooks. The LACM collection is rich in material from the northeastern Pacific and now includes the collection of Alaskan mollusks made by the late Rae Baxter. Data for most of the northeastern Pacific gastropods in the LACM collection have been computerized with NSF support.

The checklist, which includes synonyms, museum catalog numbers of holotypes, type localities, references to original descriptions and notes of synonymies, should be finished in a year. Text for the book is 30% finished. There are approximately 100 new species to be described in time for inclusion in the book.

RADULAR COMPARISON OF *CYPRAEA BICOLOR* GASKOIN, 1849 AND *C. PIPERITA* GRAY, 1829

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Conchological comparison has led Burgess (1985), Taylor and Walls (1975), Wilson (1993) and others to consider *Cypraea bicolor* synonymous with *C. piperita*, while Wagner and Abbott (1978) consider *C. bicolor* to be a subspecies. Schilder and Schilder (1971) consider them to be separate subspecies *Notocypraea piperita piperita* and *Notocypraea piperita bicolor*.

Scanning electron microscope photographs show that there are consistent differences between the radulae, and therefore suggest that *C. bicolor* may be a valid species. DNA genetic studies may be needed to refine the relationships between the direct-developing South African cowries.

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NOTES ON GENERA AND SPECIES OF ALASKAN BUCCINIDAE

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After reviewing Alaskan buccinids for my "Checklist of Shelled Marine Gastropoda of the Northeastern Pacific," I am planning to make relatively few changes at the generic level. The following are noted here: *Retimohnia* McLean, 1995, type species *Mohnia frielei* Dall, 1891, has been published (Nautilus 108:40), in order to distinguish the species with dominant axial sculpture from those of *Mohnia* Friele, 1878, in which the sculpture is spiral. *Ukko* Friele, 1893, new name for *Jumala* Friele, 1882 (ICZN rejected), type species *Fusus turtoni* Bean, 1834 [synonym *Neoberingius* Habe & Ito, 1965], is used for the Alaskan species *Beringius frielei* Dall, 1895. Species of *Ukko* have fine spiral sculpture, lack axial sculpture, and have taller spires and shorter apertures than the species that remain in *Beringius*.

Liomesus Stimpson, 1865, is reinstated over *Pseudoliomesus* Habe & Sato, 1973, following Bouchet & Waren's opinion (1985) that radular differences that purported to justify the latter are not significant. *Volutopsion* Habe & Ito, 1965, type species *Fusus castaneus* Moerch, 1858, *Volutopsion* Habe & Ito, 1965, type species *Fusus castaneus* Moerch, 1858, has relevance at least at the subgeneric level to distinguish species with axial ribs that are otherwise assigned to *Volutopsius* Fischer, 1856, in which axial sculpture is lacking.

Also noted are a new species of *Neptunea* and a new species of *Buccinum*, for which descriptions are in preparation.

SPECIES COMPOSITION AND DISTRIBUTION OF BIVALVE MOLLUSKS ON THE COMMANDER ISLANDS SHELF

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Study of materials of three hydrobiological expeditions has resulted in the detection of 63 species of bivalve mollusks on the Commander Islands shelf. Thirty of them (47.6%) are the first records for this region. Taking into account the literature data, the shelf fauna of bivalve mollusks of the Commander Islands numbers 76 species. All depths studied are grouped into three vertical ranges, 0-20 m, 40-80 m, and 100-300 m. The species composition of bivalve mollusks found within these ranges seems to be determined by the type of substratum specific to these depths. A comparative analysis of the extent of similarity of the bivalve fauna of the Commander Islands shelf with shelf faunas of Bivalvia of six North Pacific regions (the Middle and Northern Kuril Islands; Pacific Coast of Kamchatka; Southwestern Bering Sea; Anadyr Bay; Aleutian Islands; Bering Sea coast of Alaska) has been performed. In similarity of bivalve species composition the Commander Islands are closest to Kamchatka and least close to the Aleutian Islands and Alaska.

BEACH MOLLUSCAN THANATOCOENOSES IN PETER THE GREAT BAY, SEA OF JAPAN: OPEN AND SHELTERED BEACHES

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Molluscan thanatocoenoses have been studied in 35 areas on the coast of Peter the Great Bay (north-western part of the Sea of Japan). The taxonomic composition of the thanatocoenoses commonly reflects environmental variability. The shallow waters and environmental mixing does not play a significant role in the formation of those death assemblages in both open and sheltered bays. There seems to be minimal post-mortem migration of molluscan shells between open and semi-enclosed bays. It was found that heterochronous shell material of the Holocene age is a usual component of the beach thanatocoenoses in semi-enclosed, sheltered areas due to erosional action of rivers.

SPISULA SACHALINENSIS IN LIVING POPULATION, SUBFOSSIL AND HOLOCENE SHELL ASSEMBLAGES

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Abstract

We have determined the size and age distributions as well as linear growth rates of *Spisula sachalinensis* from a Popov Island (Sea of Japan) Holocene deposit, two subfossil shell communities situated on the coast (The first was located on a 30° slope near the Holocene deposit and the second on a gently sloping site closer to the sea edge); and from a living population near Popov Island (Sea of Japan). Individual age and growth rates were determined using winter inculcations of the inner layer of the shell into the outer one. These inculcations were distinguished in the radial shell cross-section. The size distributions of all samples showed one maximum for the shell height group of 70-75 mm, and the age distributions exhibited a maximum for the age group of 25-30 years. However, it was found that in transporting and burrowing stages, the information on the maximum species size was lost more rapidly than information on maximum species age. The growth rates of the bivalve species studied has not changed significantly over the last 3-5 thousand years.

Introduction

Holocene deposits of both marine and land genesis are broadly spread in the Primorsky Territory of Russia. In Peter the Great Bay, situated in the northwestern part of the Sea of Japan, well-preserved deposits are found in the island part of the Bay. In Pogranichnaya Bight of Popov Island, the Holocene deposit was formed 3-5 thousand years ago (Korotkiy et al., 1980). Macrofauna preserved in this deposit are mainly represented by molluscs. *Spisula sachalinensis* (Schrenk) is the dominant mollusc species here. The coastal shell assemblage situated between the exposed layers of the Holocene deposit and the sea was also mostly represented by *S. sachalinensis*. Evidently, this beach thanatocoenosis was formed by the wave transportation of the animals from the original living community of the bight. *Spisula sachalinensis* was the dominant component of the macrobenthos in the bight with a sandy bottom.

Spisula sachalinensis is a Pacific Asian low-boreal species. It occurs along the coast of the Primorsky Territory and Sakhalin, in shallow waters of the South Kuril Islands, near Hokkaido Island and at the north coast of Honshu Island. It inhabits open and semi-open shallow waters at surf coasts on sand sediment at a depth of 0.5-15.0 m, preferring 1.5-5.0 m (Rasin, 1934; Golikov and Scarlato, 1970; Scarlato, 1981). A method of determination of individual age and growth rates was devised for this species. It uses the annual growth bands within the shell (Yavnov & Ignatev, 1979; Zolotarev, 1989).

The purpose of this study was to reveal the differences in growth rates, age and size distributions of the samples of *S. sachalinensis* from the fossil Holocene deposit and the subfossil assemblage of dead shells situated on the beach, and from the living near-shore population.

Materials and Methods

A shell sample from the Holocene deposit (87 individuals) was taken in the central part of the coast of Pogranichnaya Bight of Popov Island (Vladivostok city, north western part of the Sea of Japan). Two samples were taken from the subfossil death assemblage on the beach of this bight. The first sampling site (112 individuals) was situated on a 30° slope near the Holocene deposit, 5-8 m from the sea edge. The second sample (107 individuals) was taken from a gently sloping site (about 10°), 0-3 m from the sea edge. The distance between these two sites was about 150 m. Live molluscs were collected by a diver from a sandy sediment of the bight at a depth of 4 m. An inadequate quantity of young molluscs were presented in the sample, as it is difficult to find their small siphons.

The individual age of each mollusc was determined by counting rings available on the radial cross-section of the shell. It is known that growth rings of the studied species are formed by the inculcation of the lower sublayer of the shell in the upper one during winter, when the growth rate is slow (Yavnov & Ignatev, 1979). The age of the majority of Holocene and some subfossil molluscs was determined by the quantity of ledges on the external surface of the shell. We think these ledges are the upper edges of the inculcations of the inner aragonite sublayer in the outer calcite sublayer (Zolotarev, 1989). Aragonite is stronger and preserves better than calcite.

Linear growth rates of the molluscs were determined from 25 individuals from each sample. The length of the molluscs at the age of 0.5, 1.5, 2.5, etc., years was determined by measuring the distance from the shell umbo to the corresponding winter growth ring because *S. sachalinensis* spawns in Peter the Great Bay in summer (Kasjanov et al., 1974).

Results and Discussion

In the Holocene deposit sample and first subfossil shell assemblage from a slope site, all shell valves were separated. Evidently, during the formation of the deposit dead shells were buried. All valves were light-colored, without periostracum. In the second death assemblage sample, the nearest to the sea, dead molluscs with remnants of the soft tissue were seldom found. Left valves were 40.5-44.4% in all samples of dead shells.

Size-frequency distributions of *S. sachalinensis* from the Holocene deposit, living population and dead assemblages had a single mode. A maximum occurred in the same size-group, 70-75 mm (Figure 1). But the upper length limits were slightly different. In the first subfossil sample from the slope site, shells with a length of 64 to 86 mm were found. In the second one, from the gently sloping site, shells had a length of 62-94 mm (one specimen with shell length 57 mm). Besides, there were fewer large shells in the first sample than in the second one (Fig. 1a, b). This is because the first sampling site is situated farther from the sea edge and higher than the second one; therefore the largest shells are more rarely cast onto the first site by storm waves. Lower limits of the shell length in the subfossil samples were practically the same. Most likely, the molluscs with shell length < 55-60 mm are mainly broken by the surf in the studied open area. In the Holocene deposit, specimens with a shell length of 57 to 80 mm were found. The lower limit was the same, but the upper one was less than both in living population and in subfossil samples. One of the most probable reasons of this was that the site of the formation of the Holocene deposit was either further from the sea edge or/and higher than both beach subfossil sampling sites. Therefore, summarizing all data, we can conclude that the studied Holocene deposit was formed on land.

Age-frequency distributions of the living population and dead shells on the beach differed (Fig. 2). Living populations had a considerably larger number of molluscs aged less than 25 years. Juveniles with fragile shells were destroyed by the waves during transportation to the burial place on the coast. Then, until the age of 25 years, the mortality rates of *S. sachalinensis* are low, and its shell is not sufficiently strong. Therefore, there were not many shells of molluscs that died at these ages in the samples of fossil and subfossil assemblages. The age of live molluscs usually was <40 years. Therefore, the dead shells were mostly less than 40 years of age. In Holocene deposit and subfossil death assemblages, the age limits of the studied mollusc species were similar, 14-46 and 16-50 (with one shell of a 1-year-old mollusc) years correspondingly. Consequently, ages close to the maximum of *S. sachalinensis* are practically the same between now and 3-5 thousand years ago. The age-frequency distribution of fossil and subfossil shell samples showed a single mode for the 25-30 year age class. At the same time, in the subfossil sample the shells of molluscs older than 30 years were more frequently found than those of individuals younger than 25 years, but in the fossil sample their proportions were the same. That is, heavy shells were fewer in the fossil than in the subfossil sample. Linear growth rate of *S. sachalinensis* during the last 3-5 thousand years was practically unchanged (Fig. 3). Using the data both on the age-frequency distributions and linear growth rates of all samples of the studied species we can draw a conclusion that the reason for the little predominance of smaller shells in the Holocene sample over the subfossil sample was not in slower growth rates of fossil molluscs. It was rather that the Holocene deposit was formed further from the sea edge and higher than the studied death assemblages.

Curves of the linear growth of modern and Holocene *S. sachalinensis* were similar (Fig. 3). Hence, the environmental conditions were similar too. The differences were statistically significant only for the age of 2-4 years. At this age, the growth rate of modern molluscs was higher than that of Holocene specimens. As the growth rate in young molluscs is higher than in old individuals at higher water temperature, it can be preliminarily assumed that the water was a little colder 3-5 thousand years ago than now.

Conclusions

1. The studied Holocene deposit was formed on land.
2. The Holocene deposit site was situated further from the sea edge and higher than death assemblages now.
3. The further the burial place of shells is from the sea edge, the sooner information concerning the maximum size of the molluscs is lost; but the information pertinent to the maximum mollusc age is lost slower.
4. Modern environmental conditions of the studied area are similar to those which existed 3-5 thousand years ago. Possibly, it was slightly colder 3-5 thousand years ago.

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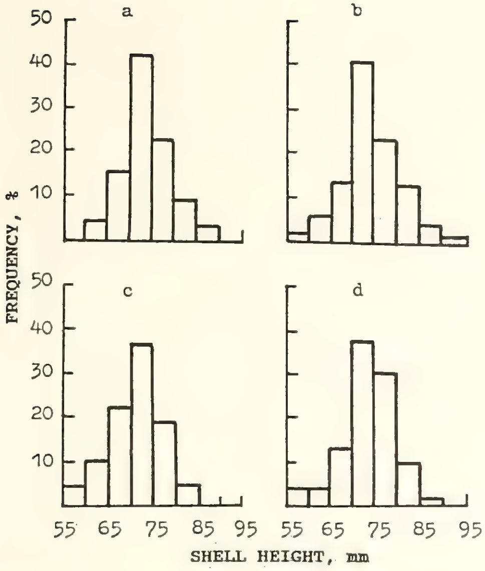

Figure 1. **Size-frequency distribution of *Spisula sachalinensis***
a) Subfossils from the slope site.
b) Subfossils from the gentle site.
c) Holocene fossil deposit.
d) Living population.

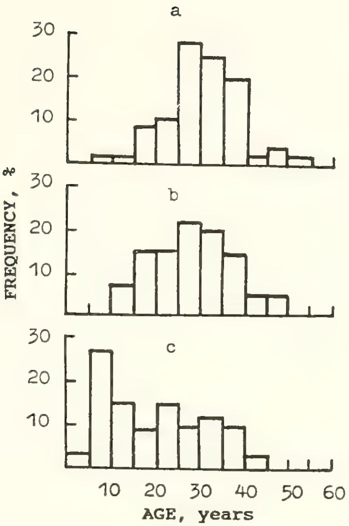

Figure 2. **Age-frequency distribution of *Spisula sachalinensis***
a) Subfossil from the slope site.
b) Holocene fossil deposit.
c) Living population.

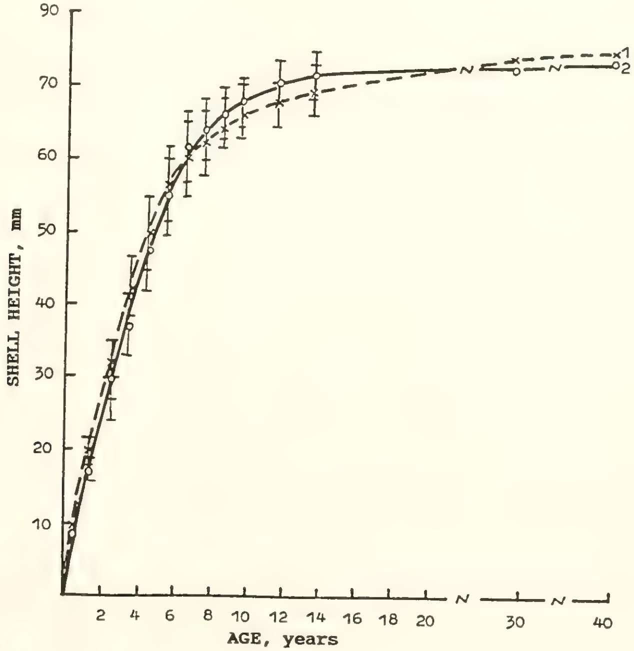

Figure 3. **Linear growth rates of *Spisula sachalinensis***

— — Living population.
—— 3000-5000 years ago.
(Vertical bars show statistical standard deviation of data.)

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RELATIONSHIPS BETWEEN FRESHWATER PEARL MUSSELS AND ATLANTIC SALMON

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The interrelations of freshwater pearl mussel *Margaritifera margaritifera* L. with Atlantic salmon *Salmo salar* L. were studied. Pearl mussel larvae (glochidia) develop in the gills of salmon. Adult mussels effectively filter river water as well as improve the bottom of the river, thus creating optimal conditions for the reproduction of salmon. In this case it seems to be a matter of a principally new form of symbiosis with time-dissociated, mutually beneficial influences of the two species. Indeed, if the parasitic glochidia are taken as a starting point, it is only the fish that at this time benefit the glochidia which find the optimal osmotic medium in their tissues, and feed and disperse at its expense. Only several years later the grown up young mussel will pay their debt by filtering water and ensuring better survival of young salmon. Thus pearl mussels and salmonid fish together form an ecological system, in which each of the species finds optimal conditions for its existence.

SYSTEMATICS OF MARGARITIFERIDAE FAMILY (BIVALVIA) IN THE PACIFIC BASIN OF RUSSIA

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There are a lot of populations of freshwater pearl mussels in the Pacific basin of Russia. They inhabit rivers of Kamchatka peninsula, Sakhalin and Kuril Islands, Maritime Province. There have been three described species of *Margaritifera* in the family Margaritiferidae (Henderson) (freshwater pearl mussels) from Sakhalin Island and the Kurile Islands of Russia (Zatravkin & Bogatov, 1987): *Margaritifera laevis* (Haas), *M. kurilensis* (Zatravkin and Starobogatov) and *M. shigini* (Zatravkin and Bogatov). These species are recognized on the basis of shell dimensions: height to length ratio and convexity to length ratio. Our investigations indicate that these ratios are highly variable and can hardly serve as discriminating characters. Values of size ratios in populations described as different species overlap. Hence there are no reasons to recognize the different freshwater pearl mussels populations from Sakhalin Island and Kuril Islands as different species. It is very likely that the rivers in this region are inhabited by only one species, *Margaritifera laevis* (Haas).

MALACOLOGICAL RESULTS OF THE 1993 AND 1994 TONGASS CAVE INVENTORY

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The authors visited several cave sites on Baker, Dall, Noyes, and Suemez Islands in the Tongass National Forest in southeastern Alaska, as part of archaeological and environmental fieldwork. "Kin n Caboodle" cave on Dall Island and the Cape Addington rock shelter on Noyes Island had assemblages of mollusk shells and shell fragments. The assemblage at the entrance of the Dall Island cave, an apparent midden, appear to have come from a diversity of intertidal habitats. Species included the chitons *Cryptochiton stelleri* and *Katherina tunicata*; bivalves *Pododesmus macroschisma*, *Clinocardium nuttallii*, *Saxidomus giganteus*, *Protothaca staminea*, *Mytilus trossulus*, *M. californianus*, and *Tresus capax*; and gastropods *Littorina sitkana*, *Fusitriton oregonenesis*, *Nucella lima*, and *N. lamellosa*. The pile also contained fish vertebrae and *Semibalanus cariosus* fragments. Charcoal found in the midden has a radiocarbon date of between 1760 and 2200 years bp. Midden shells have been dated at 2200 ± 70 years bp. *Mytilus californianus* was the only large bivalve collected at the Cape Addington site.

RECURRENT NORTHEASTWARD MOLLUSK DISPERSALS ACROSS BERING STRAIT

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Various mollusks species native to the coastal waters of Honshu, Sakhalin, and Kamchatka have made brief appearances in northwestern Alaska at various times during the past 3 million years. These temporary colonizations evidently represented fortuitous responses to occasionally favorable combinations of wind and ocean-current systems.

Bering Strait first became submerged some time between 4.2 and 3.0 mya, probably in response to slow subsidence of a broad area that encompassed much of the present continental shelves of the Bering and Chukchi Seas. Later, these shelves were repeatedly re-exposed by falling sea levels during glacial episodes and re-submerged during interglacials.

Shelly marine deposits preserved on the Alaskan coasts preserve a record of four interglacial high sea level episodes during which the shallow Bering and Chukchi shelves were repeatedly repopulated by marine organisms drawn mostly from populations that survived in the southern Bering Sea and the northeastern Pacific. However, each interglacial fauna includes a population of one or more mollusk species native to northwestern Pacific and western Bering coasts between Kamchatka and Honshu. Different exotic species appear during different interglacials, although *Natica janthostoma* recolonized Alaskan coastal waters more than once.

All the exotic mollusks were previously and subsequently endemic to the outer Asian coast between lat 45 and 60 degrees north. On the Alaskan coast, all finds lie north of the mouth of the Yukon River (lat 63 deg N). Northwestern Pacific immigrants have been found in Alaskan deposits of the Beringian I (Colvillean) transgression (ca. 2.4 mya), the Beringian II (Bigbendian) transgression (ca. 2.3 mya, the Beringian I (Fishcreekan) transgression (age unknown but between 2.1 and 1.2 mya, the Anvilian (Karmuk) transgression (0.4 mya) and the Pulukian transgressions (0.125 mya).

It seems that during interglacial intervals, rare and episodic combinations of oceanographic conditions (currents, salinity, water temperatures) have repeatedly combined to allow a few viable mollusk larvae to disperse from Kamchatka, Sakhalin, or Hokkaido northeastward to a landfall on the north shore of Norton Sound. An ocean circulation pattern quite different from the common present-day pattern would be required to permit these episodic dispersals. The airline distance from central Kamchatka to Nome is about 2,000 km, but transport through the series of eddies and counter-currents that dominate the Bering Sea would probably involve travel through distances of 3,000 to 4,000 km.

RADULAR CHARACTERISTICS OF SEVEN SPECIES OF THE GENERA *STRATONITA* RODING 1789, *PLICOPURPURA* CROSSMAN, 1903, *MUREX* LINNAEUS, 1758, AND *MURICANTHUS* SWAINSON, 1840 (GASTROPODA: MURICIDAE) INHABITING THE COAST OF MEXICO

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The radular structures were analyzed of twelve species of the family Muricidae included in four genera: *Thais*, *Stramonita*, *Plicopurpura*, and *Murex*. The studies were limited to three patterns, based on the radular structure and the preferential food type.

The intertidal plicopurpureos (*Plicopurpura panosa, P. columellaria*, and *P. patula* present an almost smooth non-serrated radula with a central split.

The thaidids (*Thais triangularis* and *T. speciosa*) from an infralittoral environment present a serrated radula without a central split.

The muricids (*Murex beauii, M. recurvirostris*, and *Muricanthus nigritus*) from a subtidal sandy environment, present a radula with the same pattern of the *Plicopurpura* genus, but without the central split. According to the type nourishment, thaidids include in their diet a greater variety of zoological groups than *Plicopurpura, Murex*, and *Muricanthus* that appear to be more specific and voracious about the species they eat. Although these three last groups are from different environments, they share a similar radular pattern.

REGISTER OF CEPHALOPODA IN THE COAST OF MEXICO ON THE GULF OF MEXICO

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A compilation of the cephalopods living and distributed in the Gulf of Mexico and bordering areas of the Mexican Caribbean Sea was elaborated based on two national and one international collections, and three national oceanographic campaigns. A total of 29 families, 61 genera, and 77 species were obtained: Order Sepioidea (cuttlefish) 8 species, order Teuthoidea (squids) 48 species, order Vampyromorpha 1 species, and Order Octopoda (Octopus) 20 species, in the area, 40 species are considered residents of the Gulf of Mexico and the adjacent Caribbean areas.

COLLECTIONS OF BIVALVE MOLLUSKS IN THE RUSSIAN FAR EAST

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There are two large collections of marine bivalve mollusks in the Russian Far East, both located at Vladivostok. One of them is deposited in Zoological Museum, Far East State University (the Museum was established in 1957/1958). The collection includes samples chiefly from Far East seas, some subtropical and tropical regions (especially southern China and Vietnam) and about 450 species of 70 families (more than 4000 specimens). Largest families are Arcidae, Mytilidae, Tellinidae, Ostreidae, Cardiidae, and Veneridae. Catalogue of this collection is currently under preparation.

The other collection is in the Institute of Marine Biology, Russian Academy of Sciences, and it was founded more than 20 years ago. The collection includes a lot of intertidal samples (especially from Kuril Islands, Kamchatka, and some regions of the Sea of Japan). Some mollusks originated from Vietnam, Australia, Papua New Guinea, etc., where expeditions of the Institute were carried out.

TERRESTRIAL MOLLUSCS OF BERINGIA

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Terrestrial molluscs of Alaska and Northeastern Asia are poorly studied. However, terrestrial malacofauna of these regions have much in common. There are no special works on land snails of Northeastern Asia. Analysis of our material and fragmentary data from some books and papers on Russian malacofauna (Likharev and Rammelmeier, 1952; Schileyko, 1984, 1986; Schileyko and Likharev, 1986) reveals 20 species and 3 subspecies, belonging to 17 genera, in 12 families.

Terrestrial molluscs of Alaska are more diverse because of the mild climate of the southeastern and south central regions. Thirty-one species and three subspecies, belonging to 22 genera, in 16 families are recorded by Dall (1905), Baxter (1987), Reger (unpublished compilation) and some other American and Russian malacologists.

The full list of land gastropods of Beringia counts 33 species and four subspecies, belonging to 22 genera, in 16 families. Alaska and Northeastern Asia have 18 species and one subspecies in common. Thus, the resemblance of their land malacofaunas is near 50%. Beringian species have different biogeographic affinities. Ten are distributed through the Holarctic, two are amphiboreal, and six (and one subspecies) are located in Beringia only.

The majority of Chukotkan terrestrial molluscs occur in Alaska too. But two species (*Pupilla limata* and *Vertigo microsphaerula*) and one subspecies (*Vallonia cyclophorella kamtschatica*) are recorded only in the Beringian region of Northeastern Asia. Alaska has two endemic snails (*Oxyloma alascana*) and (*Vallonia cyclophorella cyclophorella*). But, in the main, this area differs from northeastern Asia by 12 North American species in eight families, spread through Alaska. All mentioned data allows the assumption of at least two sources of land Mollusca species evolution in Beringia-Chukotkan and Alaskan. Species of this origin are distributed in American and Asian parts of Beringia and adjacent territories.

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TABLE 1 TERRESTRIAL MOLLUSCS OF BERINGIA

	Alaska	**N-E Asia**
Cichlicopidae		
1. *Cochlicopa lubricella* (Porro, 1838)	+	+
Valloniidae		
2. *Vallonia cyclophorella* Sterki, 1892	+	-
3. *Vallonia cyclophorella kamtschatica* Likharev, 1962	-	+
4. *Vallonia costata* (Muller, 1774)	?	?
5. *Vallonia pulchella* (Muller, 1774)	?	?
6. *Zoogenetes harpa* (Say, 1824)	+	+
Pupillidae		
7. *Pupilla muscorum* (Linnaeus, 1758)	+	+
8. *Pupilla limata* Schileyko, 1984	-	+
Vertiginidae		
9. *Vertigo modesta modesta* (Say, 1824)	+	+
10. *Vertigo ovata* Say, 1822	+	-
11. *Vertigo microsphaerula* Schileyko, 1984	-	+
12. *Columella columella* (G. Martens, 1830)	+	+
13. *Columella edentula* (Draparnaud, 1805)	+	+
Succineidae		
14. *Novisuccinea strigata* (Pfeiffer, 1855)	+	+
15. *Novisuccinea grosvenori* (Lea, 1864)	+	-
16. *Oxyloma alascana* (Dall, 1905)	+	-
17. *Oxyloma retusa* (Lea, 1834)	+	+
18. *Oxyloma hawkinsi* (Baird, 1864)	+	-
Haplotrematidae		
19. *Haplotrema sportella* (Gould, 1846)	+	-
20. *Haplotrema vancouverense* (Lea, 1839)	+	-
Punctidae		
21. *Punctum conspectum* (Bland, 1865)	+	+
Discidae		
22. *Discus cronchitei* (Newcomb, 1865)	+	-
Vitrinidae		
23. *Vitrina pellucida alascana* Dall, 1905	+	+
Gastrodontidae		
24. *Zonitoides arboreus* (Say, 1816)	+	+
25. *Zonitoides nitidus* (Muller, 1774)	+	+
Zonitidae		
26. *Retinella hammonis* (Strom, 1765)	?	?
27. *Retinella electrina* (Gould, 1841)	+	-
28. *Pristiloma arctica* (Lehnert, 1884	+	+
29. *Pristiloma stearnsii* (Bland, 1875)	+	-
30. *Hawaiia minuscula* (Binney, 1840)	+	?
Euconulidae		
31. *Euconulus fulvus* (Muller, 1774)	+	+
Helminthoglyptidae		
32. *Monademia fidelis* (Gray, 1843)	+	-
Polygyridae		
33. *Vespericola columbiana* Lea, 1839	+	-
Agriolymacidae		
34. *Deroceras laeve* (Muller, 1774)	+	+
Arionidae		
35. *Ariolimax columbianus* (Gould, 1851)	+	-
36. *Prophysaon andersoni* J.G.Cooper, 1872	+	?
37. *Prophysaon humile* (Cockerell, 1890).	+	-

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FRESHWATER MALACOFAUNA OF ALASKA AND NORTHEASTERN ASIA: SOME RESEARCH IN PROGRESS

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There is little information on molluscs of the continental waterbodies of northeastern Asia and northwestern North America. Russian and American investigators have noted considerable resemblance between the freshwater malacofaunas of the two regions (Dall, 1905; Starobogatov, 1979, 1982, Prozorova, 1986 and others). Asian (Beringian) freshwater molluscs, gastropods especially, are better known than American ones. Nineteen species, in 5 families of Gastropoda (Lymnaeidae, Physidae, Planorbidae, Valvatidae and Kolhymamnicolidae) are recorded in the Chukotka Peninsula, Koryak mountains, Chaun Lowland, Anadyr and Amguema River basin (Starobogatov and Streletskaja, 1967; Starobogatov and Budnikova, 1976; Prozorova, 1986; Starobogatov, Prozorova, and Zatrawkin, 1989). The analysis of our new information and patterns permits us to add 6 species to this list. See Table 1. It is difficult to make the same list for Alaska because data on non-marine molluscs are not sufficient. We attempted to do this on the basis of Dall's (1905) work, some fragmentary reports, Baxter's (1987) list and an unpublished compilation by Richard Reger. The list consists of 26 species, in 4 families of Gastropoda (without Kolhymamnicolidae). The full list for both Alaska and Northeast Asia counts 36 species of freshwater gastropods, fifteen of which are found in both regions.

It is difficult to check the affinity of Asian and American Bilvalva fauna because of taxonomic problems. Only 3 species of bivalves (*Beringiana beringiana*, *B. youkonensis* and *Lacustrina dilatata*) are well known to be in common for these regions. Distribution of other bivalve molluscs may be discussed only after fundamental faunistic and taxonomic studies are done. The fact is, each stage of investigation of Beringian freshwater molluscs is followed by new information on the resemblance of North Asian and North American faunas.

TABLE 1. FRESHWATER GASTROPODS OF BERINGIA

	Alaska	N-E Asia
Lymnaeidae		
1. *Lymnaea atkaensis* Dall, 1884	+	-
2. *Lymnaea petersi* Dall, 1905	+	+
3. *Lymnaea nuttaliana* Lea, 1841	+	-
4. *Lymnaea perpolita* Dall, 1905	+	+
5. *Lymnaea emarginata* Say, 1821	+	-
6. *Lymnaea vahlii* Beck, 1838	+	-
7. *Lymnaea. zazurniensis* Mozley, 1934	-	+
8. *Lymnaea kamtschatica* (Middendorff, 1851)	-	+
9. *Lymnaea. sibirica* (Westerlund, 1885)	+	+
10. *Lymnaea galbana* Say, 1825	+	-
Physidae		
11. *Sibirenauta elongata* (Say, 1821)	+	+
12. *Sibirenauta sibirica* (Westerlund, 1976)	-	+
13. *Physa chukchensis* Starobogatov & Budnikova, 1976	-	+
14. *Physa jennessi* Dall, 1919	+	+
15. *Physa skinneri* Taylor, 1954	+	+
16. *Physa kuvaevi* Starobogatov & Prozorova, 1989	+	+
17. *Physa tei* Starobogatov & Prozorova, 1989	+	+
18. *Physella nuttalli* (Lea, 1864)	+	+
19. *Physella gyrina* (Say, 1921)	+	-
20. *Physella ampullacea* Gould, 1855	+	-
Planorbidae		
21. *Anisus acronicus* (Ferrusac, 1807)	+	+
22. *Anisus substroemi* Starobogatov & Budnikova, 1976	+	+
23. *Anisus kamtshatica* (Westerlund, 1897)	-	+
24. *Anisus deflectus* (Say, 1824)	+	-
25. *Anisus circumstriatus* (Tryon, 1866)	+	-
26. *Armiger* sp.	+	-
27. *Menetus opercularis* (Gould, 1847)	+	-
28. *Promenetus* sp	+	+
29. *Promenetus exacuous* (Say, 1821)	+	-
30. *Promenetus umbilicatellus* (Cockerell, 1887)	+	-
31. *Kolhymorbis shadini* Starobogatov & Streletskaja, 1967	-	+
Valvatidae		
32. *Cincinna sorensis* (W. Dybowskii, 1886)	-	+
33. *Cincinna sorensis confusa* (Westerlund, 1897)	-	+
34. *Cincinna sorensis helicoidea* (Dall, 1905)	+	+
35. *Cincinna sorensis sibirica* (Middendorff, 1851)	+	+
Kolhymamnicolidae		
36. *Kolhymamnicola kolhymensis* Starobogatov & Streletskaja, 1967	-	+
37. *Prophysaon humile* (Cockerell, 1890)	+	-

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THE DISJUNCT DISTRIBUTION OF CERION

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The only land mollusc family restricted to the West Indies is the monogeneric land snail family Cerionidae. It exhibits a disjunct distribution pattern: a) from the Bahamas and Florida Keys west to Dry Tortuga, south to Cuba and the Cayman Islands, and east to Hispanola and Puerto Rico; b) in the "ABC Islands"(Aruba, Bonaire, and Curaçao) along the north coast of South America.

I am intrigued by the distributional hiatus between the Greater Antilles and the "ABC Islands" and the lack of *Cerion* in Jamaica, the Lesser Antilles, and the Yucatan peninsula. How can such a distribution occur? This paper looks at the possibility of human introduction.

Drymaeus virgulatus (Ferussac, 1821) is found in Puerto Rico, the northern Antilles (St. Martin and St. Eustatius), all three "ABC Islands" (Baker, 1924: 80), and mainland Venezuela. Baker believes "its remarkably discontinuous distribution...arouses the suspicion that its dissemination may be due to the agency of man" (Baker, 1924: 109).

Similarly, the introduction of *Cerion* by man could account for its distributional hiatus. To demonstrate that a species was introduced by man, we must address several issues.

- First, are there written or verbal accounts of the introduction? However, since it probably occurred in "prehistoric" times, no written accounts exist.
- Second, where are the fossil genera and species found? *Cerion uva* has been found in undated middens on Curaçao and in middens of northern Venezuela dated at 4000 years ago (Gould, 1971). *Cerion* has been found as a subfossil on St. Croix (Jacobson, 1968: 25) and on Great Inagua, Mayaguana, and East Plana Cay (Gould, 1984: 193). Pleistocene records of *Cerion* include high sea level periods 120,000 years ago during the Sangamon, on the islands of New Providence and Eleuthera (Woodruff & Gould, 1980: 397, 478; Gould, 1984: 194). *Cerion* is found in the Oligocene of Ballast Point, Tampa, Florida (Dall & Harris, 1892: 113; Henderson, 1935: 147).
- Third, where is the "birthplace" (=earliest known record) of *Cerion*? There is only one pre-Pleistocene occurrence, in the Oligocene of Tampa, Florida. There is no evidence for a South American origin (Parodiz, 1969).
- Fourth, are the species occurrences related to human habitation? *Cerion uva* is well distributed on Curaçao. Although plentiful near habitation, it is not restricted to human sites. If it were an early introduction, the human sites would have been small and scattered (as expected).
- Fifth, how variable is the species? The more "consistent," the more likely it is introduced. "*Cerion*...may be the most morphologically diverse of all pulmonate genera, with variation in shell height from 5 to 70 mm, and in shape from pencils to golf balls" (Gould, 1987: 322). "Most remarkable is the stability of the species *Cerion uva*, which seems not to have altered during many changes of the islands of Curaçao, Aruba and Bonaire in Pleistocene times, and which even did not differentiate after the scattering of the region long before" (Vries, 1974: 82). Where other species have great variability, *Cerion uva* is very consistent morphologically. All are "ribby morphotypes," indicating a Pleistocene bank-edge coast habitat. If the introduced *Cerion* stock were made early enough (4000+ years ago), could it have evolved into the present species? Some scientists believe land snails evolve rapidly.

"The modern fauna [on New Providence; the two semispecies *C. glans* and *C. gubernatoria*] are products of the last few thousand years and did not evolve directly from the *C. agassizi* fauna. *Cerion*'s evolution during this period has presumably been determined both by chance and geographic history and by the underlying population biology of the organisms themselves" (Woodruff and Gould, 1980).

- Sixth, when and where was the species in question first recorded in the area? This gives a closing date for the introduction. *Cerion uva* was described by Linnaeus in 1758 from an unknown type locality. Recent investigations report it from 4000 year old midden mounds in northern Venezuela (Gould, 1971).

• Seventh, what were the human migration or trade routes? It is not known when the first people lived in the Caribbean Islands. Evidence suggests it was about 7000 years ago or possibly earlier. These Amerindians from the Florida peninsula were called Ciboney. What little we know about them is that they hunted, fished, and gathered plants [Ed. Note: Typical preagricultural society]. Their implements were made of stone, chipped flint, wood, shells, and bone. They did not practice cultivation, make pottery, or use metal. They migrated from Florida as far south as the coast of Cuba and the Greater Antilles (Cameron & Box, 1994: 33). Others believe "St. Vincent was probably inhabited first by the Ciboneys and later by the Arawaks" (Showker, 1989: 376). The Arawaks came about 2000 years ago and the Caribs even later. They were too late and migrated in the wrong direction to have brought *Cerion* from the Greater Antilles to the "ABC's."

However, how and when did the pre-Arawak people arrive in South America? Did they come through Central America or sail across the Caribbean? Or did they move through both patterns? This issue was reviewed by Cruxent (1968: 11): "After years of trying to find an answer in archaeology and the other sciences, I believe that South America was peopled not only overland but also, and to a large extent, by sea and river routes. I do not see how men could otherwise have crossed so many rivers, swamps, and lakes with their entire families—women, children, and the aged—to occupy the whole of the South American continent." Another possible entrance route could have been through the chain of Caribbean Islands, from Florida to northern South America (Cruxent, 1968; Salzona & Callegari-Jacques, 1988: 6). If people transported *Cerion* from the Greater Antilles to the "ABC's," they had to have arrived before 4000 years ago for *Cerion* to be found in the Venezuelan middens.

• Eighth, was it transported purposely (for food or other uses), or by accident? *Cerion uva* is not used as food today, but was used extensively as food in the oldest (undated) middens on Curaçao (Gould, 1971: 1-2). It was traded to the mainland and *Cerion uva* has been identified in three 4,000 year old Meso-Indian culture agricultural sites at Lake Valencia (formerly called Lake Tacarigua), Venezuela. Lake Valencia is 20 miles inland (south) from Golfo Triste, about 50 miles west of Caracas (Berry, 1934: 393-394; Gould, 1971: 21). No recent or fossil *Cerion*s have been reported from the South American mainland (Parodiz, 1969). The locality of the species reported in 1947 from British Guiana (*C. antonii* Kuster, 1847) is believed by Clench (1957: 137) to be "probably Great Inagua, Bahamas."

• Ninth, could it have survived the journey? Cerion is a good candidate to have survived a sea journey. It is a halophile, can survive four days in complete immersion in sea water, and estivate "exposed to the blazing tropical sun for a long period" (Bartsch, 1920: 5).

• Tenth, if *Cerion* were transported by man, was it from south-to-north or north-to-south? Evidence that *Cerion* was introduced from the "ABC's" to the Greater Antilles is weak (currents are wrong, lack of fossil specimens). That *Cerion* was introduced from the Greater Antilles to the "ABC's" may be stronger, since *Cerion* was "able to gain a foothold in places where they do not come into competition with the continental species" (Baker, 1924: 112).

IN SUMMARY:

What evidence do we have for humans introducing *Cerion* from the Greater Antilles to the "ABC Islands"?

1. There are many species in the northern range and a single species in the "ABC's."
2. *Cerion* was used by Paleo-humans as a food resource in the "ABC's" and traded to Venezuela.
3. Pre-Arawaks are thought to have migrated from Florida through the Lesser Antilles to the northern coast of South America before 2000 BCE.
4. *Cerion* could have survived the sea travel.

What are the arguments against a human introduction of *Cerion* to the "ABC's"?

1. Lack of supporting evidence in the Lesser Antilles. *Cerion* has not been reported from present coastal areas or prehistoric middens.
2. Human introduction may not be needed. The hiatus can be accounted for by our lack of knowledge regarding disjunct distributions.

More data are needed before a decision can be made.

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KARYOLOGICAL ANALYSES OF POPULATIONS OF THE FRESHWATER SNAILS *PHYSA* FROM THE LAKE OF XOCHIMILCO, MEXICO

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Physid snails have been used as a toxic-influence index and a biochemical evaluation method of the effects of pesticides on living organisms (Karnaukhova et al., 1991). The main objective of this work is to contribute cytogenetic level information, that is, karyological criteria, to the environmental studies serving to preserve and improve aquatic resources.

From microscopic slides obtained through standard cytogenetic techniques, only the mitotic fields that show the best resolution in chromosome morphology were selected from the Xochimilco area in Mexico City.

The diploid number found in the analyzed karyotypes showed a value of 34 chromosomes, that is, $2n = 34$. There is no evidence of sexually dimorphic chromosomes.

The chromosomes of the genus we studied were of the biramous type. Each chromosome presents two chromosomal arms, yielding a fundamental number of 68, consisting of the metacentric, mediocentric and sub-metacentric type chromosomes.

I thank Dr. Jorge Carranza Fraser of the Laboratorio de Limnología del Instituto de Ciéncias del Mar y Limnología de la UNAM for the use of his laboratory.

Literature Cited

Karnaukhova, T. B., L. N. Korobova, and E. M. Reikh. 1991. Superoxide dismutase activity as an index of toxic action of pesticides. Biologicheskie Nauki (Moscow) (5): 146-149.

NEW DATA ON THE FRESHWATER MALACOFAUNA OF THE KURIL ISLANDS

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Summer 1994 field investigations were carried out on the four southern islands of the Kuril Archipelago: Iturup, Kunashir, Shikotan and Zelyoniy. Study of the collected material reveals new information on the molluscan fauna, biogeography and eoclogy. The main results are as follows:

1. More than 70 species of freshwater gastropods and bivalves are found on the Southern Kuril Islands. Eleven species and five genera are new to the region; 21 species are new to science.

2. None of the island species inhabit the Asian continent. On the contrary, the southern Kurils, Japan (primarily Hokkaido) and south Sakhalin have some species in common.

3. Kuril malacofauna differs from the continental fauna: there is less biodiversity, a complete absence of some families and genera, and greater numbers of species of certain genera (*Henslowiana, Musculium*). Such families as Pachychilidae, Bithyniidae, Acroloxidae, Bulinidae, Physidae and some widespread East Asian genera--*Amuropaludina, Choanomphalus, Kolhymorbis, Helicorbis, Pisidium*--are not present in the southern Kuril Islands.

4. Biogeographically the Kuril malacofauna is heterogeneous. Genera and subgenera with Chinese, Japanese, Palearctic and American origins are present in the fauna. The Chinese faunal elements prevail among gastropods and large bivalves. Small bivalves are primarily Palearctic.

5. Changes in the ecology of some species may be caused by the influence of increased humidity, lower and less variable temperatures, and reduced insolation in the Kuril Islands. For example, some *Euglesa* Leach in Jen. (subgenus *Roseana*) and even *Conventus* Pir. et Star. inhabiting deep continental lakes were collected on the south Kurils in amphibious biotopes.

SOME DATA ON THE GENUS *CECINA* A.ADAMS (GASTROPODA, POMATIOPSIDAE)

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Russia representatives of the amphibious genus *Cecina* inhabiting shoal and supralittoral zones of the Japan Sea were studied. Eight species are present in the study area. (Six will be described as new to science.) Typical species that occur throughout the area include *C. manchurica* A.Adams, 1861, *C. tatarica* (Schrenck, 1867) and one unpublished species. The other five unpublished species are found only in the southern Kurile Islands and perhaps in Japan. Separate species are distinguished by the different shell shape, radula and structure of the aperture. Reproductive anatomy of all six new species looks like that of *C. manchurica*. Species of *Cecina* are difficult to identify by traditional conchological methods because of decollated embryonic shell. It is better to use the "comparatorial" method of Ya. I. Starobogatov. Nowadays this heuristic system is accepted by the majority of Russian freshwater malacologists because it permits the independent comparison of all four of Raup's parameters and, in addition, a fifth, the dimension of the upper base of the truncated cone of the shell-tube.

Minutes
Executive Board Meeting
Western Society of Malacologists
Chena Hot Springs, Alaska
1 June 1995

Called to order by President Nora Foster at 3:52 p.m.

Present: Nora Foster, Hugh Bradner, George Metz, Terry Arnold. Observer Marge Bradner.

Secretary's Report: Terry Arnold read the Minutes of 1994 Board of Directors and Business meetings. The Board accepted the minutes as read.

Treasurer's Report: See attached Report. Accepted as read.

Student Grant Committee:

43 applications from 8 countries.
Winner will be announced 31 July.
$1000 allocated.
1996 allocation $1000; more if available.

Motion to reimburse Nora Foster additional Symposium costs of $775. Seconded and passed.

Nominations:

President	Hugh Bradner
First Vice President	Henry Chaney
Second Vice President	Sandra Millen
Secretary	Terry Arnold
Treasurer	George Metz
Members at Large	Don Shasky Kirstie Kaiser

Publications:
Paul Scott is preparing the1994 Annual Report. Hugh Bradner has volunteered to be Production Editor of the 1995 Annual Report, with instructional support by Paul Scott.

1996 Meeting: will be held at Handlery Hotel and Country Club on Hotel Circle, San Diego, 23-27 June, 1996. Room rates will be $60 single or double. There will be no meal package; there is easy access to many restaurants. There will be an auction. Planned field trips include fossil beds and Hubbs Sea World Research Institute. SCUBA dives can be arranged. Planned symposia are Functional Morphology and Natural History of Molluscan Feeding; Biology of the Cypraeacea; and Promises & Problems of Invertebrate DNA research.

Related dates: COA St. Petersburg FL 15-19 June.
AMU Chicago, IL 29 June - 3 July.

Motion that the 1996 meeting report be accepted as presented. Motion was seconded and passed.

1997 Meeting: Santa Barbara, Joint with AMU 22-26 June.

There being no further business, the meeting was adjourned at 2:05 p.m. by President Nora Foster.

Respectfully submitted by Terry S. Arnold, Secretary.

Minutes
Annual Business Meeting
Western Society of Malacologists
Chena Hot Springs, Alaska
5 June, 1995

The meeting was called to order by President Nora Foster at 1:35 p.m. Eleven members attended.

Secretary's Report: The minutes were read and accepted.

Treasurer's Report: Was read and accepted.

Student grants: (Preapproval) Motion that grants will be approved by the Board of Directors upon recommendations by the Student Grants Committee. Motion passed. 1996 Student Grants: Distribute a maximum of $1000.

Nominations:

President	Hugh Bradner
First Vice President	Henry Chaney
Second Vice President	Sandra Millen
Secretary	Terry Arnold
Treasurer	George Metz
Members at Large	Don Shasky Kirstie Kaiser

Nominations from the floor were invited. None were proposed. A motion to accept the slate of officers as proposed was made, seconded, and passed.

1996 WSM Meeting: President-elect Hugh Bradner reported that the 1996 Annual Meeting of the WSM will be held at the Handlery Hotel and Country Club on Hotel Circle, San Diego, 23-27 June 1996. Rooms will be $60 for single or double. There will not be a meal package; there are many good restaurants nearby. Field trips being considered include fossil beds, Hubbs Research Institute and SCUBA dives. There will be an auction. Three symposia are anticipated: Functional Morphology and Natural History of Molluscan Feeding; Biology of the Cypraeacea; Promises and Problems of Invertebrate DNA.

Related Dates: COA St. Petersburg Florida 15-19 June, 1996.
AMU Chicago Illinois 29 June - 3 July, 1996.

1997 WSM Meeting: Joint meeting with AMU in Santa Barbara, 22-26 June, 1997.

President Nora Foster adjourned the meeting at 2:05 p.m.

Respectfully submitted by Terry Arnold, Secretary.

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT

1 October 1994 - 30 September 1995

INCOME

Membership dues	$1969.00	
Student Grant donations (1994)	1020.00	
Symposium fund	351.50	
Interest on savings and other sources	384.02	
Royalties	409.64	
TOTAL INCOME during period		**$4134.16**

EXPENSES

Administrative (Fees, Dues, Officer expense, Office expense)	322.61	
1995 Student Grant	1625.00	
1995 Symposium expenses	1500.00	
TOTAL EXPENSES during period		**$3,447.61**

Net Gain	686.55
Balance brought forward 1994	2,979.06
Balance	3,665.61
Savings (Does not include interest)	10,000.00
NET WORTH 1 OCTOBER 1995	**$13,665.61**

STUDENT GRANT RECIPIENTS WERE:

Daniel Geiger.....$825
Allan Hancock Foundation
233, Department of Biological Sciences
University of Southern California
Los Angeles, CA 90089-0371

David Carlini.....$800
Virginia Institute of Marine Science
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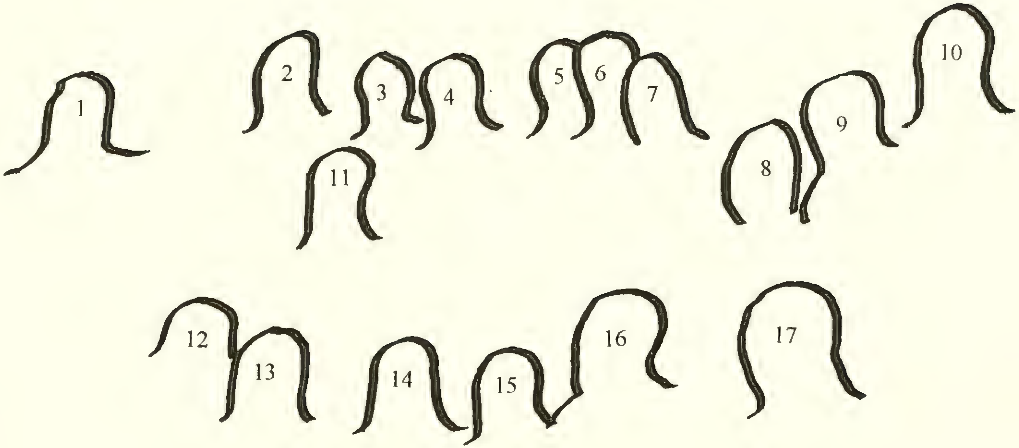

1995 Annual Meeting Group Photograph
Chena Hot Springs, Alaska
5 June, 1995

1.	George Metz
2.	Roma Metz
3.	Neil Fahy
4.	Marge Bradner
5.	Marty Arnold
6.	Michael Donovan
7.	David Hopkins
8.	Rachael Hopkins
9.	Charlotte Norrid
10.	Jim McLean
11.	Hugh Bradner
12.	Debra Levin
13.	Nora Foster
14.	Anne Knowlton
15.	Larisa Prozorova
16.	Maria Diupotex
17.	Terry Arnold

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